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REDESIGNING ACQUISITION PROCESSES: A NEW METHODOLOGY BASED ON THE FLOW OF KNOWLEDGE AND INFORMATION

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The original title of this project was "Developing a Methodology for Redesigning Acquisition Processes Based on Information Load Analysis." The new title of this report is slightly different to better reflect the final outcomes of the project. We would like to thank the External Research Acquisition Program coordinators, particularly Mark Nissen, for their relentless and generous support. We would like to also thank the employees of Computer Sciences Corporation and Lockheed Martin as well as the officials from the Department of Defense who participated in this project.

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ABSTRACT

Current business process redesign practices, in the defense sector as well as in business in general, are based on several assumptions inherited from Taylor's scientific management method, including the key assumption that activity-flow representations should provide the basis for business process redesign. While this assumption was probably correct for most organizations in the early 1900s, it is clearly inconsistent with the fact that, currently "information" is what flows the most in business processes, even in manufacturing organizations. This project is based on the key assumption that the current focus of business process redesign approaches should be on information flows rather than activity flows.

The main goal of this project is to develop a methodology for redesigning acquisition processes based on knowledge and information-flow analysis. The methodology, called InfoDesign, focuses on the knowledge embedded in a business process, the information processing resources involved in execution of the process, and the information flowing through the process. The InfoDesign methodology was developed and partially validated during a one-year project. The validation of the methodology was conducted as an action research study in which one acquisition process involving the U.S. Government and one key supplier was analyzed and redesigned. The results of the study support the key assumption on which InfoDesign was built — that current business process redesign approaches should focus on information flows rather than activity flows.

ORGANIZATION OF THIS REPORT

This report is divided into five chapters. A description of each of these chapters is provided below:

- **Chapter 1: Research Problem, Goals, and Plan.** This segment of the report discusses the motivation of the research project and its main goals. It also provides details about the project schedule, main deliverables, and potential impact within the defense sector and elsewhere.

- **Chapter 2: Conceptual Foundation.** This segment of the report discusses the concept of process as well as several popular views of processes, with particular attention to the *data-flow* and *work-flow* views. It also discusses three fundamental concepts — data, information and knowledge. This discussion is particularly important because of the rather confusing way in which these terms are used in both academic as well as more popular ways. We offer new conceptualizations that suggest that data is a carrier of information and knowledge; and, while information is eminently descriptive, knowledge is mostly predictive in nature. Although these conceptualizations are heavily based on previous theoretical frameworks from cognitive science and artificial intelligence, we tried to eliminate technical jargon as much as possible and explain our views through examples involving simple day-to-day situations.

- **Chapter 3: The InfoDesign Methodology.** This segment of the report discusses the InfoDesign methodology, which was developed as part of this project. A methodology for process redesign is necessarily made up of guidelines that are followed by those employing it. Since those guidelines should be defined for each step of the methodology, there are usually many of them, several of which may appear disconnected and coming out of nowhere. Given this, key principles that are used as a basis for the creation of guidelines are discussed in this chapter.

- **Chapter 4: The Need for a Shift in Redesign Focus.** This segment of the report argues that current business process redesign practices, in the defense sector as well as in business in general, are based on several assumptions inherited from Taylor's scientific management method, including the key assumption that activity-flow representations should provide the basis for business process redesign. It also argues that the current focus of current business process redesign approaches should be on information flows rather than activity flows. This point is at the source of the development of the InfoDesign methodology.

- **Chapter 5: Validating InfoDesign through an Action Research Study.** In this chapter, the point made in Chapter 4 is formalized by means of a hypothesis, which is tested through an action research study of a business process redesign project. The project results in the redesign of a software development procurement process involving the Department of Defense (DoD) and Computer Sciences Corporation. The study supports the claim by showing that the members of a business process redesign team voluntarily favored the use of InfoDesign, which is based on an information-flow approach to business process redesign over a traditional approach based on activity flows.

CHAPTER 1
RESEARCH PROBLEM, GOALS, AND PLAN

Problem Statement

The economic environment surrounding organizations in virtually every industry is undergoing change at a pace that has never been experienced before. This is caused by several factors, including the fast development of new technologies, the emergence of new competitors, and market pressure for changes. New technologies enable increases in productivity, customer satisfaction, and market reach. As capitalism spreads throughout the world, new competitors emerge from unlikely quarters, such as firms from other industries or countries that were not previously major competitors in world trade. Information about features of highly competitive services and products is quickly disseminated, driving market pressure for change (Kock, 1998). These forces not only push suppliers to continuously redesign their business process to keep their acquisition process effective and competitive but also push buyers into similar patterns of change so they can take advantage of new products and forms of delivery (Davenport, 1993; Deming, 1986; Harrington, 1991).

In addition to the accelerated pressure for change, the nature of work has become more complex and specialized as new knowledge is continuously created and incorporated into the production of goods and services (Davenport et al., 1996), mirroring a larger-scale trend towards knowledge specialization and fragmentation (Hayek, 1996). Products and services are, thus, increasingly more sophisticated and knowledge intensive, requiring the involvement of a variety of experts, each holding a key piece of specialized knowledge to be produced and delivered. It has been shown that, as knowledge becomes more specialized and fragmented, the information flowing among individuals holding different types of expertise increases substantially (Kock and McQueen, 1996; 1998) and, in many cases, leads to an "information overload" (Evaristo et al., 1995; Kock, 1999).

Current business process redesigning, which focuses on work flows (or activity flows), is inconsistent with the above trends. In fact, many aspects of the current trend have been referred to as modern-day versions of older techniques. These older methods include the mechanistic methods, based on the "time-and-motion" analysis developed from the early notions of Adam Smith (1910; 1910a), and the subsequent development of scientific management methods by Taylor (1911). New process redesign methods are needed. These new methods should focus on knowledge management and information flow. While their main goal is to fill a methodological gap, these new methods can complement and potentially replace existing methods based on work flows.

Goal and Approach

The goal of this project is to develop a methodology for redesigning acquisition processes based on knowledge- and information-flow analysis. This methodology, called InfoDesign, focuses on the knowledge embedded in a business process, the information processing resources involved in execution of the process, and the information flowing through the process. While the development of

InfoDesign is one of the components of this proposal, the methodology combines, develops, and refines specific aspects of one previously published methodology and two theoretical frameworks listed below:

- **MetaProi** stands for Meta Process for Process Improvement (Kock, 1999a). MetaProi is a refinement of the PROI methodology (Kock, 1995) and is a process redesign method focused on information-flow streamlining.

- **Theory of Constraints** (Bramorski et al., 1997; Goldratt, 1990; Goldratt and Cox, 1986; Goldratt and Fox, 1986). One of the hypotheses of this theory is that a focus on "bottlenecks" leads to optimal business process design, from both an efficiency and effectiveness perspective. Bottlenecks are defined as subprocesses (or activities) that pose constraints on process cost reduction and reduce throughput. In other words, the theory hypothesizes that, if process redesign is conducted (based on the identification and redesign of bottlenecks), the process will be accomplished cheaper and faster and without any impact on process redesign quality than if no focus on bottlenecks occurs.

- **Information Load Theory** (Evaristo et al., 1995). The term "information overload" has been used in the business literature without first considering the true meaning of "information load," the underlying construct. This theoretical treatment suggests that there are several antecedents of information load, some affecting demand for information processing resources and others affecting the supply of these resources. "Information load" is how much of the supply is being used by the demand for these resources. In particular, knowledge about the demand antecedents can be invaluable in controlling the level of information load and, therefore, the potential performance in certain tasks.

InfoDesign is used in this research project for the identification of "information-flow bottlenecks" in business processes. Building on MetaProi, a set of guidelines is developed to restructure business processes based on process modeling and analysis outcomes. Information-load theory is used for the preparation of these guidelines by providing a conceptual basis for the optimization of information loads. Part of the objective is to avoid letting the load become too low or too high, situations that are likely to lead to lower performance levels.

The InfoDesign methodology was developed and partially validated during a project lasting approximately 1 year. The project's main tasks and subtasks are described in the Project Schedule (see Appendix A). The validation of the methodology was conducted as an action research study (Checkland, 1991; Elden and Chisholm, 1993; Kock et al., 1997; Winter, 1998) in which one acquisition process, involving the U.S. Government and one key supplier, was analyzed and redesigned. The process redesign proposal was cross-evaluated for quality and for the likely organizational impact by stakeholders of the organizations involved. This was performed immediately after its delivery and before its implementation. Six months after the delivery of the process redesign proposal, a review of its implementation was conducted to assess its bottom-line impact on process efficiency and quality.

The following table lists potential suppliers, who were initially contacted and who have partnered with the researchers in previous projects; products; and respective buyers within the

U.S. Government. We eventually partnered with Computer Sciences Corporation and Lockheed Martin for this research project. Each of the two companies contributed a group of employees to work on the redesign of a software acquisition process involving the Department of Defense and Computer Sciences Corporation. (Lockheed Martin often partnered with Computer Sciences Corporation to develop software products.)

Supplier	Products	Buyer (U.S. Government)
Computer Sciences Corporation http://www.csc.com	Software	U.S. Navy
Day & Zimmerman http://www.dayzim.com	Munitions	U.S. Army
Lockheed Martin http://www.lockheedmartin.com/	Rockets and aviation equipment	U.S. Air Force, NASA
Concurrent Technologies Corporation http://www.ctc.com	High-end simulation equipment	U.S. Navy

Project Deliverables

This project has one main deliverable — a methodology, which is described as a set of activities, guidelines, support forms, and graphical tools for redesigning acquisition processes. (The graphical representations used in this report are independent from current computerized process-modeling tools.) The main stages of this methodology include:

(a) Process modeling that is focused on knowledge distribution, information processing resources, and information flow;
(b) Identification of "information-flow bottlenecks" in acquisition processes;
(c) Information-flow analysis focused on the bottlenecks identified in stage (b);
(d) Process redesign based on the analysis performed in stage (c); and
(e) Implementation of process redesign changes.

In addition to the methodology discussed in detail in this report, other deliverables include a dissemination web site and several publications. These are described later in this chapter under the heading "Dissemination of Results." This final report includes a detailed discussion of the action research study used for the validation of the methodology, conclusions, and suggestions for future research, refinement, and application of the methodology.

Potential Impact and Significance

Based on the amounts of money involved in U.S. Government acquisition processes, it is clear that even small improvements can result in large savings. We expect that the InfoDesign methodology will contribute to such improvements.

Due to resource scarcity — not only physical equipment but also knowledge and human resources — and the increasing irrelevance of geographical location to establish a business, it is likely that a higher percentage of projects will be distributed in nature in the near future. Therefore, we do anticipate that this research project will also have another important consequence in the future. Given the emphasis on information flows, which usually occur asynchronously and independently of geographical location, the knowledge generated by this research project will be particularly useful in the redesign of acquisition processes involving several geographically distributed suppliers.

Dissemination of Results

The results of this project are being disseminated through the following main outlets: A support web site, two conference papers, and two journal articles. The conference papers and journal articles are available from the support web site (the versions on the web site do not incorporate editorial changes). These outlets are discussed below.

Support Web Site

This web site contains a description of the project; documents developed during the project, including the final report on the project; and several multimedia components discussing key project issues. The web site is available at www.mis.temple.edu/earp.

Conference Papers

1. Kock, N. and Murphy, F. (to be submitted), "Communication as the Focus of Business Process Redesign: An Action Research Study of Defense Contractors," International Conference on Information Systems [December 2001, Boston, MA].

2. Kock, N. (submitted Feb 2001), "Web-driven Management Thinking: A Look at Business Process Redesign in the Age of the Internet," IFIP Conference on E- Business [October 2001, Zurich, Switzerland].

Journal Articles

1. Kock, N. (submitted Feb 2001), "Changing the Focus of Business Process Redesign from Activity Flows to Information Flows: A Defense Acquisition Application," *Acquisition Review Quarterly*.

2. Kock, N. (accepted, forthcoming), "Managing with Web-based IT in Mind: A Simple Framework Based on Practice," *Communications of the ACM*.

3. Kock, N. (2000), "Benefits for Virtual Organizations from Distributed Groups," *Communications of the ACM*, V.43, No.11, pp. 107-113.

The support web site and any publications based on this project leave out and/or disguise classified information and any details deemed confidential by the project participants.

CHAPTER 2
CONCEPTUAL FOUNDATION

Process Views: Focusing on Certain Aspects of Processes

As a concept becomes more abstract so does the discrepancy in the ways different people construe its meaning. A concept that refers to a tangible object, like that of a *chair* for example, is likely to be understood more or less in the same way by two people. With abstract concepts, such as those used in a *process,* however, understanding is much less likely to be achieved without further clarification. One of the reasons for this difficulty is that abstractions are not perceived by our five senses as "real" objects (like a chair that we can see and touch) and, therefore, must be understood based on abstract models. If these models do not exist or if they are too rough and incomplete, a sense of perplexity often develops.

As with most abstract entities, processes need to be modeled so people can understand them and, more importantly, so two or more people can understand them in roughly the same way. Irrespective of how complex, models are limited representations in most cases, whether of real objects or abstract entities. A representation of a transistor, for example, can help one predict how it will behave (e.g., amplify an electrical input) when an electrical impulse of a certain voltage is applied to it. Still, the same representation can be almost useless when predicting the operation of the same transistor if the input is an alternating current with a frequency above a certain level (e.g., as in analog telecommunication circuits). Similarly, a certain representation of a car, such as a diagram in an owner's manual that explains the basic operation of the car, can be detailed enough for someone who wants to *drive* the car yet useless to someone who needs to *repair* the car. In fact, perhaps the only characteristic that is shared by all models is that they are all incomplete.

A few main types of process models or views are discussed in the following subsections. As discussed above, these views lead to *incomplete* representations of processes and, therefore, should be understood in terms of their pros and cons in today's information- and knowledge-intensive organizational environments.

The Work-flow View of Processes

Although there seems to be little agreement on what a process is or the main elements that make it up, the predominant view among academics and practitioners seems to be that a process is a set of *interrelated activities* (Hunt, 1996; Ould, 1995). In this sense, processes are seen as activity flows (a.k.a., *work flows*) composed of activities that bear some sort of relationship with each other (White and Fischer, 1994). This means that, if activities are not perceived as interrelated, they are not part of the same process.

Among activities in processes, there are at least three main types of relationships, which we refer to as: (a) c*ommon predecessor*, (b) *common successor*, and (c) *predecessor-successor*. These relationships are illustrated in Figure 1.

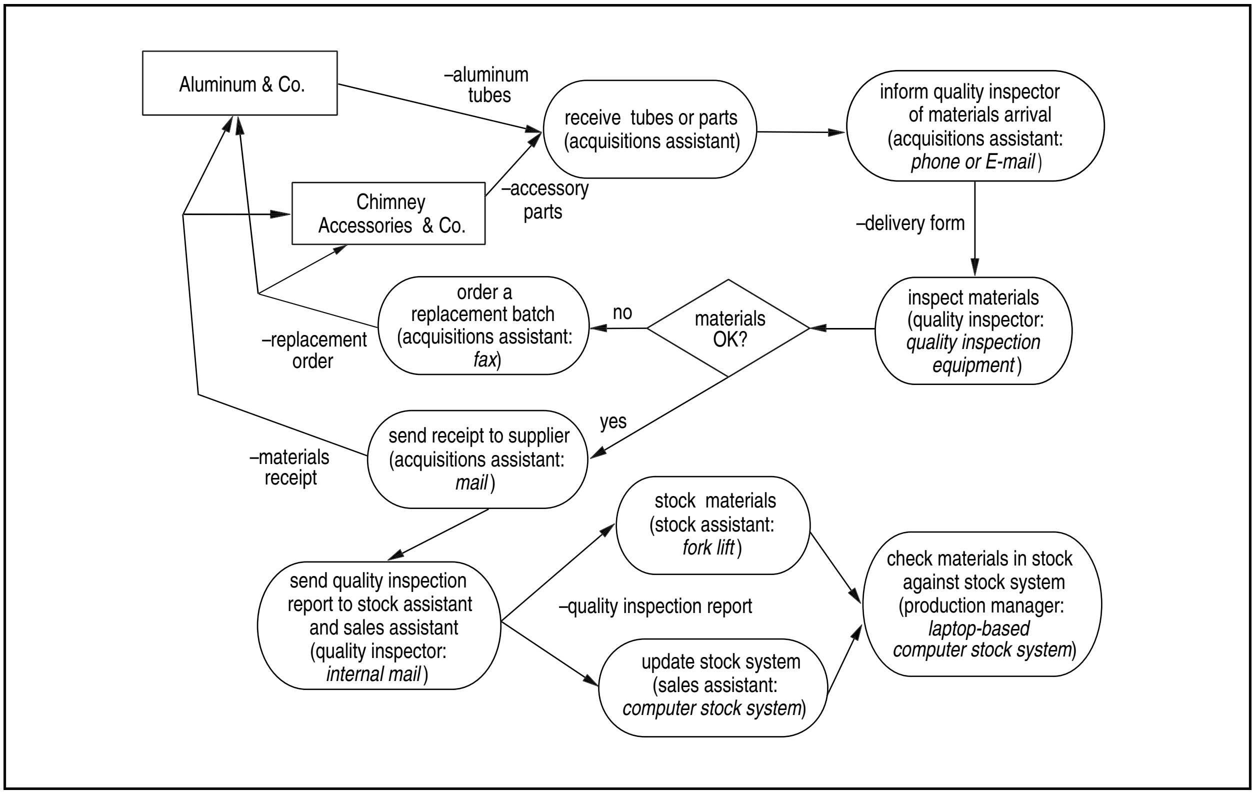

Figure 1. "Receive Materials" Process of a Chimney Manufacturer.
Adapted from Kock et al. (1997a, p. 72).

In this figure, activities are shown within oval shapes, and the arrows indicate the flow of execution of the activities in the process. Also, a rectangular shape represents an external supplier of the process, whereas a diamond shape indicates a decision point in the process. Each activity is described by its name and followed (within parentheses) by the organizational function that carries out the activity and the italicized name of the main tool used by this function. Freestanding text that begins with a "dash" is used to describe a "product," which can be a piece of data or a material thing that flows between activities.

The ***common predecessor*** relationship joins together activities that have a common immediate predecessor activity. In the Figure 1 process, this relationship is shown by the activities *order a replacement batch*, which is carried out by the acquisitions assistant (usually by fax), and *send a receipt to supplier*, which is also carried out by the acquisitions assistant, who typically uses ordinary mail. Both activities have the same immediate predecessor — the *inspect materials* activity — that is done by the quality inspector, who uses specialized quality inspection equipment. This *common predecessor* must be carried out before each of these two interrelated activities.

The ***common successor*** relationship connects activities that have a common immediate successor activity. The activities *stock materials* and *update stock system* (the former done by the stock assistant with the use of a forklift and the latter by the sales assistant on a computerized stock system) are connected through a *common successor* relationship. Both activities have a common successor — the activity *check materials in stock against stock system* — which is performed by the production

manager by walking through the stock warehouse and comparing it with the inventory database by using a laptop-based version of a computerized stock system.

The ***predecessor-successor*** relationship, the most common type of relationship between activities, joins together two activities that take place in sequence, one after the other. Note that, as with the two types of relationships described above, a *predecessor-successor* relationship can exist even if there is no flow of data or materials between activities. The activities *receive tubes or parts* and *inform quality inspector of materials arrival* are connected by a *predecessor-successor* relationship as they can only be carried out in sequence, the second after the first.

The process of creating work-flow representations of processes is typically called flowcharting. According to Harrington (1991, p. 86), this process is "… an invaluable tool for understanding the inner workings of, and relationships between, business processes." Irrespective of this opinion, however, work-flow representations of processes, such as those in Figure 1, illustrate an important point — although flowcharts can show the data or materials that flow between activities in a process, these data or materials *do not actually flow* between activities. Hence, the data-flow representation in flowcharts can be somewhat misleading. For example, the delivery form, which apparently flows between the activities *inform quality inspector of materials arrival* and *inspect materials*, in reality flows between the organizational functions that carry out these activities — acquisitions assistant and quality inspector. The delivery form is a data repository that allows for the exchange of information between these two functions. This shortcoming of the work-flow view can be of significant importance if the focus of a process redesign attempt is on the flow of data, not the activity configuration in a process. This is because the work-flow view "hides" information about the flow of data in organizational processes (Kock and McQueen, 1996).

There are a number of variations of work-flow representations similar to the one shown in Figure 1. The work flow in Figure 1 itself is an adaptation of the ANSI standard flowchart, and it has been extensively used in our work with process improvement groups. (See Kock (1995; 1999a) for a description of the use of this flowcharting tool in process improvement groups.) Flowchart variations include the block diagram, functional flowchart, functional timeline flowchart, and geographic flowchart. (See Harrington (1991) for a more detailed discussion of these.)

The Data-flow View of Processes

Another traditional view of business processes is through data flows, where processes are seen as data processing entities. Data-flow representations have been largely used in the 1980s by systems analysts as an important component of what are known as *structured* systems analysis and design techniques (Davis, 1983) — a predecessor of the *object-oriented* analysis and design approach (Somerville, 1992).

Data-flow representations have been used chiefly to understand the flow of data within processes and, later, to automate this flow "as is" rather than to redesign processes. This "automation-of-old-processes" approach has been the target of strong criticism in the early 1990s and has often been described as the main cause of the low return on investment in information technology (IT) observed in both the 1970s and 1980s. The service sector has been particularly affected by IT's low return on

investment, which has steadily declined to even negative figures; and IT investment has led to a *decrease* in productivity in a number of service industries, such as banking and insurance (Hackett, 1990).

Like the work-flow view of processes, the data-flow view can be expressed through a family of graphical representations, from which the most widely used is the *data-flow diagram* (DFD) (Gore and Stubbe, 1988; Pressman, 1987). An example of a DFD obtained from the analysis of the flow of data between the restaurants and the central kitchen of an Italian restaurant chain is shown in Figure 2. In this figure, a rectangular shape represents a data source or destination — the restaurant manager and the central kitchen manager functions. Arrows indicate the flow of data, which are described by freestanding text located beside the arrows. Oval shapes represent activities. Open-ended rectangles represent data repositories.

The process mapped through the DFD in Figure 2 starts with a chain restaurant manager, who tells the manager of the central kitchen, where all dish items are prepared, that the restaurant is short of some specific items (e.g., Bolognese sauce, spaghetti, Italian bread). The manager of the central kitchen then fills out a form, specifying what items are out-of-stock and which restaurant needs them. This form is then placed in the assistant manager's in-box. Approximately every 2 hours, the assistant manager of the central kitchen goes through the forms in the in-box, generates the orders to be prepared by the cooking team, and stores the orders in the out-box. When scheduling, the assistant manager tries to optimize the work of the cooking team by grouping requests that require the same resources (e.g., ingredients, cooking equipment). The cooking team then collects the orders from the assistant manager's out-box and prepares the Italian dish items ordered on a first-come, first-served basis. They also pack and stock these items in the delivery room as soon as they are ready. Delivery

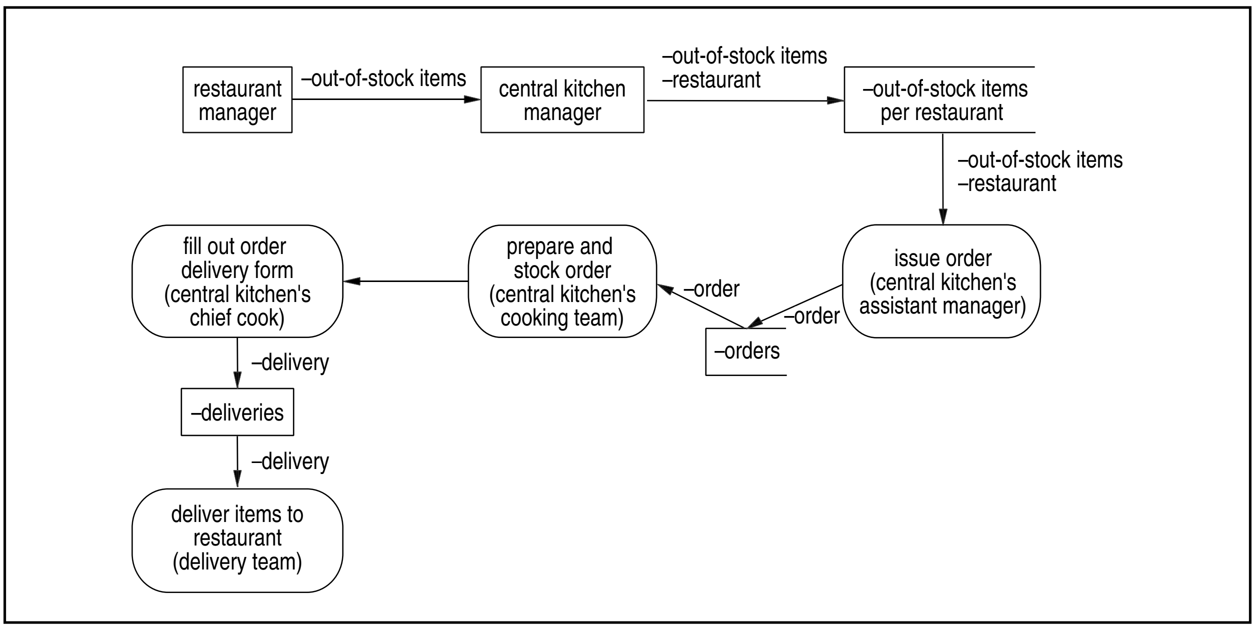

Figure 2. "Fulfill Order" Process of a Central Kitchen at an Italian Restaurant Chain.
Adapted from Kock (1995, p. 44).

forms are filled out and attached to each of the packaged items for the restaurants, which are periodically delivered by the central kitchen's delivery team.

Although an incomplete model of real processes, representations based on the data-flow view of processes, such as DFDs, show the flow of data and how it is stored in a relatively clear way. As such, one can reasonably expect these representations, in some cases, to be more appropriate than representations based on work flow, such as flowcharts. This is true especially in the analysis of processes where the flow of data is particularly intense.

A dramatic increase in the flow of data has been predicted as one of the characteristics of today's and the near future's economy, particularly in the developed and developing countries (Drucker, 1989; Toffler, 1970; 1991). Hence, it is reasonable to expect that representations based on the data-flow view of processes become more useful in process improvement attempts than representations based on the work-flow view. As mentioned before in this chapter, the latter type of representations tend to provide a poorer picture of the flow of data, preventing the identification of, for example, data "buffers." Data buffers are organizational functions (rectangular shapes in DFDs) that perform the job of transferring data among other organizational functions. In a given process, these "buffers" are, therefore, strong candidates to be removed from the process and replaced by information technology applications. This is the case in Figure 2, where the function *central kitchen manager* acts as a buffer between the restaurant manager and the assistant manager of the central kitchen. In the process analyzed, the manager of the central kitchen receives data from the restaurant manager and stores it in a data repository that will be used as input by the assistant manager of the central kitchen to generate an order. A more efficient version of the process would have the restaurant manager storing this data with no mediation of the manager of the central kitchen, who could use that time to do other things.

How much detail should be in the diagram when mapping processes through either flowcharts or DFDs? The activities in a process representation can be seen as subprocesses themselves, which can, in turn, be broken into new activities. In fact, seeing the activities of processes as lower-level processes and generating more-detailed diagrams by "exploding" these lower-level processes is a common practice in both flowcharting and DFD generation (Davis, 1983; Maull et al., 1995; Pressman, 1987). In doing so, however, two simple guidelines are suggested (Kock and McQueen, 1996):

- Each graphical representation of a process should not have more than 14 activity symbols.
- In a process improvement context, the *breadth* of improvement sought should define the level of detail when modeling processes.

The first guideline is based on studies about general human cognitive limitations relating graphical representations and diagrams used in systems analysis and design (Kock, 1995a). The second guideline is based on a relatively new concept — the *breadth* of process improvement (Hall et al., 1993). Roughly speaking, the breadth of improvement correlates the number of different departments or distinct areas affected by process improvement decisions. The larger the breath of improvement, the less process detail is necessary. If one wishes to improve processes that cut across several (perhaps all) of the departments of an organization, the process representation should comprise little detail

about subprocesses that belong to individual departments. As a general rule of thumb, the total number of high-level processes used to effectively represent any organizational unit can be anywhere between 10 and 20 (Hammer and Champy, 1993; Maull et al., 1995).

Other Process Views

Although the two previously discussed process views — the **work-flow views** and the **data-flow views** — are the most relevant ones for the purposes of this project, there are other views of processes. Among these are the **systems view** and the **object-oriented view**, briefly discussed below.

The Systems View

The systems view of processes is based on the traditional concept of *system* — an assembly of parts that cannot be understood just in terms of its components. A system can be defined by its *emergent properties*, which are *system* properties and, therefore, meaningless in terms of the parts that make up the system. This concept is illustrated in the following excerpt by Checkland and Scholes (1990, p. 19):

> The vehicular potential of a bicycle is an emergent property of the combined parts of a bicycle when they are assembled in a particular way to make the structured whole.

According to the systems view, a process can be operationally defined as an abstract entity that represents the transformation of inputs into outputs (Childe et al., 1994; Childe, 1995; Kock, 1995a). In a process, suppliers provide inputs, and customers consume outputs. The transformation of inputs into outputs is aimed at adding value to the customers of the process. The inputs and outputs of a process may be of three different types — goods, services, and data (Juran, 1989; Kock and Tomelin, 1996).

While philosophically appealing, the main problem with the systems view of processes is that it adds little to our understanding of the inner workings of a process and, therefore, may be of little use to those who try to change the process. In the system view, processes are defined by means of sets of emergent properties that characterize them; the relationship between their components is of secondary importance.[1]

In spite of its limitations, the systems view has proven to be more useful than the work-flow view in the analysis of very complex (and often "messy") processes, such as those related to strategic decision making. These processes typically *cannot* be analyzed as work flows because, among other things, the number of activities and decision points required to represent them is too large to allow for effective modeling.

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[1] We are referring mainly to the British systems perspective here, which has been highly influenced by Peter Checkland and colleagues. Another systems view of processes that is popular in American research circles, particularly in the field of operations research, focuses on managing and coordinating complex interactions, e.g., global warming. This other systems view later evolved into the so-called "chaos theory."

The Object-oriented View

One of the main proponents of the object-oriented view of processes is Ivar Jacobson, who developed a methodology to model processes as data objects. Jacobson's methodology was based on the concept of the *software object* (Jacobson et al., 1995). A software object is a data repository with a number of associated operations. These operations are also called *methods* in the technical jargon of object-oriented analysis and programming (Thomas, 1989). A software object typically stores data in its attributes, which are analogous to the attributes of real objects like a chair (e.g., the attributes of an object *chair* are its *color*, *weight*, and *number of legs*) (Partridge, 1994).

The object-oriented view can be seen as an extension of the data-flow view in which data repositories, represented in DFDs by open-ended rectangles (see Figure 2), are permanently linked to activities that change the content of those repositories. There is a clear advantage in adopting this view. Many believe that object-oriented programming is increasingly becoming the dominant software development paradigm (i.e., it has been adopted by most of the major players who were active in the software development industry during the 1990s). Also, the object-oriented view of processes allows for an inexpensive transition between: (a) process analysis and redesign, and (b) the development of new computer systems to support the implementation of the new redesigned processes.

However, the object-oriented view has been criticized for its excessively technical orientation, which prevents less sophisticated users (i.e., those who are unfamiliar with object-oriented concepts) from effectively understanding it in its full complexity and adopting it in process improvement projects. Process analysis and design methodologies using object-oriented representations, such as the Unified Modeling Language (UML), are still too complex to be widely accepted and used in organizations in spite of the fact that UML has been endorsed by several "heavyweights" in the computer community (Meyer, 1998). This has been compounded by the fact that, among less sophisticated users, there are often senior managers who are usually absorbed in strategic management issues and, therefore, do not have the time to become technically sophisticated. The problem with this situation is that the support of such managers is a fundamental ingredient in successful process improvement initiatives (Davenport, 1993).

Moreover, some recent software industry developments have turned the building of customized computer systems (often "in-house"), which is facilitated by the adoption of the object-oriented view of processes, into an often undesirable and expensive alternative. Buying and customizing of-the-shelf applications and enterprise resource planning systems as well as outsourcing data and application management to enable new organizational processes are seen by many as more desirable approaches made possible by such developments.

Data, Information and Knowledge: Different Words for the Same Concept?

We hear the words "data," "information," and "knowledge" quite often being used as if they were synonymous; but are they actually the same thing? If not, what are the differences?

The contribution of IT providers has perhaps been unmatched in its potential to add to our confusion over the distinction between data and information. Examples can be found in almost any specialized IT publication, conversations with IT company representatives, and even in public speeches by IT "gurus." For example, a senior vice-president of a large software development company was one of the keynote speakers of a recent information systems conference. He referred to the advantages of a well-known commercial group support system in the following terms:

> "… information overflow can be considerably reduced … for example, a few weeks ago I prepared a 2 megabyte report and sent it via electronic mail to ten people. Each of these ten people forwarded a copy of the report to about ten other people … as a result, my report had generated a flow of 200 megabytes of information in the network, in less than four days …"

In the example above, the speaker was referring to data, which can be measured in megabytes, as synonymous with information. This can often be misleading because large sets of data may have very low information content, depending on how well the data receiver is prepared to make sense of it. Mistakenly identifying data as information is as commonplace as confusing knowledge with information.

It is curious that the confusion over what information and knowledge are has been nurtured by some of those people who are widely recognized as among the forerunners of the study of information and knowledge and their impact on organizations and society. For example, one of the most highly regarded management consultants and researchers, Peter Drucker (1989, pp. 207-208), describes the emergence of the information-based organization in the following terms:

> … the business, and increasingly the government agency as well, will be *knowledge*-based, composed largely of specialists who direct and discipline their own performance through organized feedback from colleagues and customers. It will be an *information*-based organization … Today's typical organization, in which knowledge tends to be concentrated in service staffs perched rather insecurely between top management and the operating people, will likely be labeled a phase, an attempt to infuse *knowledge* from the top rather than obtain *information* from below [our emphasis].

If information and knowledge were the same thing, why use two words when just one would suffice? Even though information and knowledge mean different things to different people, most people use them in different senses. The main reason these two words are often used interchangeably is exactly because there is no agreement over their meaning.

But, why should we worry about the different nature of data, information, and knowledge? One reason is because an ocean of data may contain only a small amount of information that is of any value to us, and sifting through this ocean of data may be severely time-consuming (Goldratt, 1991). But there are other reasons, and they relate to our understanding of the world.

The world is not only what we perceive it to be through our senses; it is a combination of these perceptions and what is stored in our body, mostly in our brain in the form of neural networks (Callatay, 1986; Dozier, 1992). We can develop our neural networks by interacting with matter and living organisms, notably other human beings. However, in order to interact with other human beings, we need to externalize what is stored in our neural networks by means of a code. Other human beings must understand this code so communication takes place.

If data and information are the same, how can the content of one E-mail message be interpreted differently by various recipients? Let us suppose that an E-mail message, written in Spanish (a specific code), is sent to two different recipients. While one of the recipients can read Spanish very well, the other cannot. In this example, the message takes up the same disk space (say, 3.6 kilobytes) on the computers of each of the recipients, which is a measure of the amount of *data* related to the message. Yet, its *information* content is much higher for the recipient who can read Spanish than for the recipient who cannot.

If data and information are the same, then they should not yield different "amounts" when measured for the same object (in this case, the E-mail message in Spanish). It is important to stress that different terms could have been used in this discussion; for example, instead of "data" and "information," "alpha-stractum" and "capta" could be used. The more commonly used terms *data* and *information* are used in this report because we believe that the sense in which we have just used these two terms is their most "usual" sense.

The distinction between knowledge and information is a bit more abstract than the distinction between information and data. In order to make this distinction as clear as possible, consider the following dialogue between a doctor (D) and her patient (P):

D: So, what brings you here today?

P: I don't know doctor, I've been feeling a bit strange in the last couple of weeks.

D: What do you mean by "strange"?

P: Burning eyes, stuffy nose … and these things go and come several times a day.

D: Any headaches or fever?

P: No, not at all.

D: Well, we'll run a checkup on you, but I think you probably have an allergy.

The patient was feeling the symptoms of what could be an allergy and, therefore, went to see the doctor, an expert who likely *knows* more about medicine than the patient. The patient described the symptoms, and the doctor made the tentative diagnosis, "*… you probably have an allergy.*" Is what the patient told the doctor enough for anyone without any medical expertise to come up with the same tentative diagnosis? Well, if this were the case, very few people would agree to pay doctors for consultations. Doctors possess more of something the patients do not have, something typically referred to as *knowledge*, in the specific field of medicine.

Is the nature of the expert knowledge possessed (by the doctor, in this case) the same as that of the perception of symptoms experienced by the patient? No, for the simple reason that expert knowledge can be used to generate conclusions based on the description of symptoms. This is something that the descriptions alone cannot do. Therefore, the natures of *descriptions* and *expert knowledge* are different, and it can be shown that neither of them is the same as the nature of data. This also suggests that descriptions are instances of something unique — referred to here as *information*.

Data are Carriers

In the usual sense of the term, *data* are considered carriers of information and knowledge. The flow of data in organizational processes among the functions that carry out process activities takes place through various media, particularly, paper, digital electrical impulses (e.g., electronic data interchange systems), analog electrical waves (e.g., telephone), electromagnetic waves (e.g., radio), and air vibrations (e.g., face-to-face conversation). Data can also be stored for later use on different storage media, such as magnetic media (e.g., hard and floppy disks), paper, and volatile digital memories (e.g., RAM memory in personal computers).

Data are either transferred or stored through a process of "changing" or generating perturbations on a given medium. A blank sheet of paper, for example, can be used for data storage (e.g., to write down an address of a friend) or transfer (e.g., to write a memo to an employee by applying ink to paper). Or, from a more business-oriented perspective, if a machine operator wants to tell his supervisor about a problem with a metal-shaping machine, the operator can approach the supervisor and speak face-to-face. In doing so, the operator uses vocal cords to generate vibrations in the air (volatile data) that will be received and decoded by the recipient through hearing organs.

Data will only become information or knowledge when it is interpreted by human beings (Kryt, 1997) or, in some cases, by artificial intelligence. (See Russel and Norvig, 1995, for an example.) As data can be stored and transferred by process functions through applying changes to storage and communication media that will be interpreted by other process functions, an operational definition within the context of process management might be as follows:

> If John performs an organizational function, such as carrying out an activity in an organizational process, then the *data* are permanent or volatile changes applied to a communication medium by John to store or transfer information or knowledge. These will later be used by John or someone else (or an artificial intelligence agent) to perform an organizational activity.

The measurement of data depends on the medium used to store or transfer it as well as on the code used. In most organizational processes, data can be measured in words or symbols, when the medium used is paper, and in bits or bytes (1 byte is a group of 8 bits), when the medium used is a digital one.

In many ways, a bit can be considered the smallest and most fundamental unit of data. It can take only two values: 0 (or false) and 1 (or true). A group of 8 bits forms a byte; and, since the number of

possible bytes is 2^8 or 256, there can be a direct correspondence between bytes and certain symbols (e.g., the letters of the English alphabet and other alphabets). One such set of symbols, which is largely used to convert alphanumeric characters into bytes and vice-versa, is called the ASCII code (American Standard Code for Information Exchange). Most computer operating systems use the ASCII code, or an extended version of it, to map symbols that have meaning to human beings (e.g., letters and numbers) into bytes stored in any of the computers' data storage devices (e.g., RAM, hard disk, etc.).

Information is Descriptive

A hot issue in business circles in the 1990s has been the advent of the "information society," the "information era," and the "information-intensive" organizations. However, any discussion regarding these issues should, of necessity, focus on the nature of information. What is it? Is it a specific kind of entity? If yes, how can we differentiate information from other similar entities? These are core questions in the continuing debate within a number of disciplines, such as information systems, management science, engineering, and philosophy. A substantial portion of the literature in these disciplines is devoted to defining information, however, as Budd and Raber (1996, p. 217) note in the following:

> In the course of doing so [i.e. defining information], many aspects of information (technical, physical, semantic, epistemological) are featured as part of the discussion. Part of what emerges is a multifaceted idea and thing that is, at times, defined in terms of what it is not. For instance, information is not merely data; organization and intended meaning transform the bits of data into something that can inform.

From a process-oriented view, information can be seen as carried by data and as being eminently *descriptive*. From a linguistic perspective, the typical instance of information is the utterance called *assertion*. One example of assertion is: "Today is a sunny day." Independently of what this assertion means exactly (the word "sunny" can mean different things to different people, from sparsely clouded to clear-sky weather), it provides a *description* of the current state of the environment surrounding us. If the environment is seen as an object, the assertion can be seen as defining an attribute of the object, in this case, the *weather* as *sunny*.

Information can be qualified in different ways. It can be more or less complete or accurate; and it can refer to the past, present, and future. For example, the assertion, "Today is hot!" conveys less accurate information than the assertion, "Today's average temperature is 85 degrees Fahrenheit." Both assertions describe the present, that is, today. The assertion, "The temperature on this day during the last 3 years has averaged 87 degrees Fahrenheit," provides information about the past. The assertion, "Tomorrow the top temperatures will be in the low 90s," provides a description of the future. Although similar to descriptions of the past and the present, descriptions of the future, by their own nature, *always* carry a certain degree of uncertainty.

Knowledge, which will be discussed in more detail in the next section, is often used to generate more information based on information at hand. The information thereby generated (or *inferred*) is usually not obvious and, therefore, possesses some added value in relation to the primary information

received as an input by the knowledge holder. One example is the generation of information about the future (e.g., the weather in New York tomorrow) based on information about the present and past (e.g., the weather patterns in New York during the last 2 years) up to now. This type of information about the future is produced by meteorologists, based on their knowledge about the science of weather forecasting. It is then purchased by news services that, in turn, broadcast the information to their audiences and, in the process of doing so, manage to make a profit.

The Value of Information

One interesting aspect of information is that it has value — how much someone is willing to pay for it and can benefit from it. In general, this seems to directly correlate some of its attributes. Among these attributes, it has:

- *Advanceness*, that is, how much time in advance it describes the future (if it refers to the future rather than to the past or present);
- *Accuracy*, that is, how accurate the description is; and
- *Completeness*, that is, how complete the description is.

Let us explain the different nature of the attributes above in a business context. The "corporate war" between Coca-Cola and Pepsi in the 1980s was largely one of product differentiation (Ramsey, 1987). Both Coca-Cola and Pepsi tried to increase their shares of the "cola" soft drink market by launching new differentiated (e.g., diet) products ahead of each other. Consider the similar situation of two companies, A and B, competing for 2 million customers in the same industry. Each customer consumes a product supplied by both companies. Analogous to the "cola" war, the product is essentially the same, the main difference being the brand. Each customer consumes 70 units of the product, which costs $3 each, every year; this makes it a $420 million per year market. Company A has 90 percent of the market or $378 million, while Company B has the other 10 percent or $42 million. Both companies sell with a pretax profit margin of 17 percent, which yields approximately $64 million for Company A and $7 million for Company B in absolute pretax profits.

Now, suppose Company B decides to launch a new product into the market, whose development time is approximately 9 months. The product has the potential to bring Company B's market share up to 20 percent, and send Company A's share down to 80 percent. This would raise Company B's pretax profits up to about $14 million and make Company A's profits plummet to nearly $57 million. From Company A's perspective (the value of information always depends on its user and the context), one piece of information — the information that Company B is going to launch a new product — can make a big difference. This piece of information can have a high *advanceness* if it is provided to Company A well in advance of the product launch, which would enable Company A to take appropriate countermeasures. The same piece of information can have a high *accuracy*, providing accurate details about the product that is going to be launched (e.g., it might include the precise date of launch). The information can also have high *completeness* by providing a rich description of the new aspects of the product (i.e., the new flavor, amount of saturated fat, sweetener used, etc.).

If Company A has no access to information about the new product launch and obtains some imprecise information a few weeks before the new product is launched, it will have to endure a loss in pretax profits of $7 million — the worst-case scenario. However, if it gets accurate and complete information early enough, it can take preventive measures whereby it can at least reduce its losses. For example, if the information is obtained more than 9 months in advance (i.e., has high advanceness) but leaves uncertainty about the characteristics of the product (i.e., has low accuracy and completeness), Company A might have to develop a range of new products to dampen the potential impact of Company B's new product on the market share. Its profits may still be reduced due to increased product development costs.

Having access to detailed information about Company B's new product (i.e., highly accurate and complete information) only 4 months before the launch (i.e., low advanceness information) may lead to a similar end result; that is, Company A may be able to develop an intermediary product that will reduce the impact of Company B's new product on market share.

Perhaps the best scenario is that, if Company A has access to highly detailed information (i.e., highly accurate and complete information) about Company B's new launch early enough (i.e., the information has high advanceness), it can develop a similar new product and get it out into the market before Company B. According to our initial assumptions, this could potentially bring Company A's market share up to 95 percent and increase profits by about $4 million.

In the example above, no information or information with low accuracy, completeness, or advanceness, would be of low value to Company A. Information with high accuracy and completeness, but low advanceness (or vice versa) would have a medium value as it could prevent a loss of $7 million in pretax profits a year. Finally, information with high accuracy, completeness, and advanceness would have a high value, enabling an increase in profits of $4 million a year. This relationship between information value and its attributes is illustrated in Figure 3.

Although the example above is concerned with a decision-making process at the strategic level, the relationship between information value and the attributes advanceness and accuracy can be extrapolated from most organizational processes. Simply put, process-related information seems to be an important enabling factor for the members of a process team (i.e., those who perform process activities) to do their job efficiently and effectively, whatever the process is.

	Low Accuracy and Completeness	**High Accuracy and Completeness**
High Advanceness	Medium Value	High Value
Low Advanceness	Low Value	Medium Value

Figure 3. The Value of Information.

Knowledge is Associative

While information is eminently descriptive and can refer to the past, present, and future, knowledge is highly *associative*. That is, knowledge allows us to "associate" different world states and respective mental representations. These representations are typically linked to, or described by, pieces of information (i.e., knowledge allows us to link different pieces of information and make decisions based on associations). The associative aspect of knowledge can be divided into two types, namely **correlational** and **causal**, which are, in turn, only two types of what is referred to by Weick and Bougon (1986, p. 104) as "cognitive archetypes."

Correlational knowledge usually connects two or more pieces of information that describe events or situations that have happened, are happening, or will happen at the *same* time. **Causal knowledge** connects pieces of information that describe the state of the world at *different* times. For example, consider the associative knowledge represented in the following decision rule: "If John has a fever and is sneezing, then John is likely to have a cold." The knowledge embodied in this decision rule is of the correlational type because it affirms that someone who has a fever and sneezing is, in fact, displaying typical cold symptoms (i.e., "fever," "sneezing," and "cold") typically happen at the same time.

Another example of a different type of knowledge is provided by the rule, "If John smokes a lot, then he will probably die from lung cancer." This decision rule expresses causal knowledge. As such, the rule connects two events that take place at different times — John smokes a lot in the present, and John may dye of lung cancer in the future. Dennett (1991, p. 144) refers to causal knowledge when he claims that:

> The brain's task is to guide the body it controls through a world of shifting conditions and sudden surprises, so it must gather information from that world and use [it] *swiftly* to "produce future" — to extract anticipations in order to stay one step ahead of disaster [original emphasis].

Knowledge drives the flow of myriad decisions that have to be made even in the simplest organizational processes. Steel plants, for example, rely on process teams to load and operate smelters. Consider the predictive knowledge expressed in the rule, "If the smelter is set at a temperature of 3,000 degrees Celsius, then a 1-ton load of steel will be smelted in 43 minutes." This is one of the pieces of knowledge that allows a smelter operator to predict that a batch of solid steel weighing about 1 ton will be in liquid form approximately 43 minutes after it is loaded into the smelter, if the smelter is set properly. This prediction allows the smelter operator to program a stop in the smelting process at the right time and let the liquid steel flow out of the smelter, which saves energy and, at the same time, prevents the steel from overcooking.

For teamwork to yield effective and efficient outcomes, those who perform activities in a process must share predictive knowledge. In the example, those who use the steel in liquid form for shaping steel parts should ideally hold at least part of the knowledge held by the smelter operator. If they know of the "43 minute rule," they can also predict that a batch of steel will be ready 43 minutes from the time it is loaded in solid form and have their own equipment prepared at the right time to work on the liquid steel.

In general, business knowledge is inextricably linked with decision making (Olson and Courtney, 1992; Holsapple and Whinston, 1996), perhaps because one of the best ways of assessing the actual value of knowledge is through the assessment of the outcomes of decisions made based on it. Holsapple and Whinston (1996, p. 6) talk of the importance of knowledge for decision making:

> For centuries, managers have used the *knowledge* available to them to make *decisions* [original emphasis] shaping the world in which they lived. The impacts of managers' decisions have ranged from those affecting the world in some small or fleeting way to those of global and lasting proportions. Over the centuries, the number of decisions being made per time period has tended to increase. The complexity of decision activities has grown. The amount of knowledge used in making decisions has exploded. There is no sign that these trends are about to stop. If anything, they appear to be accelerating.

Knowledge has been distinguished from information. It is also linked with decision making in different fields of research and academic disciplines. In the field of artificial intelligence, for example, information has been typically represented through "facts." Knowledge, on the other hand, has been expressed by means of a number of different representations, such as semantic networks, frames, scripts, neural networks, and production rules; the latter is the most common in practical knowledge-based computer systems (Callatay, 1986; Holyoak, 1991; Olson and Courtney, 1992). Production rules are conditional statements in *if-then* form, like the ones used to exemplify knowledge in this section.

In the fields of psychology and social cognition, knowledge has been expressed through schemas (Lord and Foti, 1986) and cognitive maps (Weick and Bougon, 1986). These are, in turn, seen as guiding individual and group behavior and using, as input, environmental stimuli obtained through the senses. The concept of schema was developed as a reaction to studies of memory pioneered by Ebbingaus, who made use of arbitrary materials and sensorial stimuli to determine factors that influence the formation of memory and recall of information (Gardner, 1985). The development of the concept of schema is credited to Bartlett (1932), who used an Indian folktale called "The War of the Ghosts" to show that existing mental structures strongly influenced memory formation and recall. Such existing mental structures, which were used by Bartlett's study subjects to process information coming from the tale, were called schemas. Essentially, Bartlett has shown that individuals possessing different schemas would interpret the tale, which is filled with strange gaps and bizarre causal sequences, in substantially different ways.

In biology (more particularly in neurology) knowledge is typically associated with long-term, nerve-based memory structures that mainly process information (Pinker, 1997). Information is seen as usually associated with short-term neural connections that appear to "vanish" from conscious memory after a while. For example, the knowledge of how to operate a telephone is stored in long-term memory structures, whereas the information represented by a phone number is stored in short-term memory structures.

The Value of Knowledge

Knowledge is usually much more expensive to produce than information. For example, information in the form of mutual fund indicators (e.g., weekly earnings, monthly price fluctuation, etc.) is produced by means of simple calculations performed on data about share prices and their fluctuation over a time period. The knowledge of how mutual fund indicators fluctuate, however, requires years of analysis of *information* built up over time. This analysis of information leads to the development of knowledge that allows an expert investor to select the best mutual funds according to the configuration of the economy. This leads us to the question: How is knowledge produced?

Comparative studies of experts and nonexperts suggest that expertise is usually acquired through an inductive process in which generalizations are made based on the frequency with which a certain piece of information occurs. These generalizations are the basis for the construction of knowledge (Camerer and Johnson, 1991).

A different and less common method used to generate knowledge is deduction, whereby hidden knowledge is produced based on existing knowledge taken through a set of logical steps (Teichman and Evans, 1995). This method has been used in the development of a large body of knowledge in the form of "theorems," particularly in the fields of mathematics and theoretical physics (Hawking, 1988).

An example of knowledge-building through induction is that undergone by novice investors in the stock market. The observation that shares of a small number of companies in high technology industries have risen10 percentage points above the Standard & Poor's 500 Average Index during a period of 6 months may prompt novice investors to put all of their money into these shares. However, a professional investor with10 years experience as a broker in the stock market knows that a 6-month observation period is not long enough to support such a risky decision and opts for a more diversified portfolio. In cases such as these, a novice will probably sell, based on the same pattern used when buying, and will eventually lose money. These decisions were based on inferences based on a time span that is too short, leading the novice investor to buy shares that are overvalued and sell these shares when they are undervalued. According to Boroson (1997), most nonprofessional investors follow this recipe, which, in most cases, leads to disastrous consequences.

The example above illustrates a key finding from research on cognitive psychology — people usually tend to infer knowledge based on the observation of a small number of events, that is, on limited information (Feldman, 1986). Moreover, once knowledge structures are developed, changing these structures can become more difficult than developing them from scratch (Woofford, 1994). A conversation that one of us (Ned Kock) recently had with a university colleague illustrates these cognitive biases. The colleague had gone to two different agencies of the New Jersey Motor Vehicle Services (MVS) where he met employees who lacked sympathy and friendliness. He also had gone to a similar agency in Pennsylvania, whose employees he found to be very nice. Later, during a chat with friends, he said:

> "… All MVS employees in New Jersey are very grumpy, difficult to deal with … The state of Pennsylvania is much better in that respect …"

He had just made a gross generalization, given the small sample of MVS agencies visited — two in New Jersey and only one in Pennsylvania. Although he agreed this was a generalization, he was nevertheless adamant that he would never go to a New Jersey MVS agency again, unless it was absolutely necessary. If this was the case, he said he would ask a less "touchy" person to go — his wife.

The development of theories of knowledge (or epistemologies) and scientific methods of inquiry has been motivated by a need to overcome cognitive biases as illustrated above. This has been one of the main common goals of such thinkers as Aristotle, René Descartes, Gottlob Frege, Bertrand Russell, Karl Popper, and Thomas Kuhn. Epistemologies and scientific methods have provided a basis for the conduct of research in general and, in consequence, for technological advances that have shaped organizations and society. Every year hundreds of billions of dollars are invested in research with the ultimate goal of generating highly reliable and valid knowledge. And the market value of organizations is increasingly assessed based on the amount of knowledge that they possess rather than on their material assets base (Davidow and Malone, 1992; Toffler, 1991).

Paul Strassmann, a former information technology executive at organizations such as Xerox, Kraft Foods, and the U.S. Department of Defense, suggests that variations in the perceptions of organizational knowledge account for the growing trend toward overvaluing or undervaluing common stocks in the share market. According to Strassmann, the perception that a stock is overvalued stems from the failure of current accounting systems to account for the knowledge assets of organizations, and he presents an impressive array of data to support this idea. Abbott Laboratories is one of the companies he used to illustrate this point.

Over a period of 7 years from 1987 to 1994, the ratio between Abbott's market value (defined by stock price), and its equity has swung from five up to nearly eight and back down to about seven. However, the ratio between market value and "equity-plus-knowledge assets" remained almost constant over that period, smoothly gravitating around two. This supports Strassmann's (1997, p. 13) position that the market perceives the accumulation of knowledge assets, which is reflected in the high correlation between share prices of organizations and their knowledge assets, even though the knowledge assets are not shown on a company's balance sheet:

> The sustained stability of the market-to-capital ratio, which accounts for the steady rise in the knowledge capital of Abbott Laboratories confirms that the stock market will recognize the accumulation of knowledge as an asset even though the accountants do not. The stock market will also reward the accumulators of knowledge capital because investors recognize that the worth of a corporation is largely in its management, not its physical of financial assets.

When we move from a macroeconomic to a microeconomic perspective and look at the business processes of a firm, the trend toward valuing knowledge seems to be similar to the one just described. Knowledge allows for the prediction of process-related outcomes, from the more general prediction of acceptance of a new product by a group of customers to much more specific predictions, such as slight manual corrections needed on a computer board surface after it goes through an automatic drill. Correlational knowledge enables process-control workstation operators at a chemical plant to link a

sudden rise of an acidity gauge to an incorrect setting of the flow through a pipe valve. This enables the operators to take the appropriate measures to bring the acidity level down to normal.

The workers who hold bodies of expert knowledge are rewarded according to their ability to perform process activities in an efficient and effective way. This is typically done through linking different types of information, which can be done through formal educational or personal experience (i.e., the building of mental knowledge bases), and generating information about the future based on information about the past or present (i.e., predicting the future). Organizational wealth is closely linked to the ability to build and use technological artifacts to control future states of the (economic, physical) environment in which organizations operate. However, this control is impossible without the related ability to predict the future, which, in turn, relies heavily on predictive knowledge.

Organizational knowledge is believed to be the single most important factor that ultimately defines the ability of a company to survive and thrive in a competitive environment (Davidow and Malone, 1992; Drucker, 1995). This knowledge is probably stored mostly in the brains of the workers of an organization, although it may also be stored in computer systems and databases (Alster, 1997; Strassmann, 1996; 1997) and other archival records (e.g., printed reports).

Whatever form it takes, knowledge is a commodity; and, as such, it can be bought and sold, which makes its value fluctuate according to the laws that regulate supply and demand. Abundant knowledge, which can be represented by a large number of available professionals with the same type of expertise, becomes cheap when supply surpasses demand, which is typically reflected in a decrease in the salaries of some groups of professionals. On the other hand, a situation in which some types of highly specialized knowledge are in short supply, while demand grows sharply in a short period of time, can lead the knowledge holders to be caught by surprise when faced with unusually high bids by employers. For example, Web Java programmers were being offered salaries of up to $170,000 early in 1996, even though the demand for their new expertise was virtually nil until 1995. This was the year Java was first released by Sun Microsystems and 2 years after the University of Illinois began the distribution of its World Wide Web browser Mosaic.

Linking Data, Information, and Knowledge

Although they are different conceptual entities, data, information, and knowledge are inextricably connected. This may be one of the reasons why they are so often confused. As discussed before, data are perturbations on a communication or storage medium that are used to transfer or store information and knowledge. Therefore, knowledge and information can neither be communicated nor stored without data.

Information is used to describe the world and can provide a description of the past, present, and future. (Information about the future always carries a certain degree of uncertainty.) Correlational knowledge allows for the linking of different pieces of information about the present. In this case, usually some of the information pieces are obvious and are used as a departure point; and the other pieces are hidden and allow for relevant decisions. Predictive knowledge enables the production of information about the future, typically based on information about the past and the present; that is, information is generated based on both correlational and predictive knowledge. However, the reverse

relationship is also valid; that is, knowledge can be generated based on information. In fact, the main means by which reliable knowledge is produced is the systematic analysis of information about the past. This analysis typically leads to the observation of patterns that are combined into predictive and associative rules (i.e., knowledge).

The following case involves Hopper Specialty, a retail vendor of industrial hardware in Farmington, New Mexico, and NCR, a large developer of computer hardware and software, headquartered in Dayton, Ohio, (Geyelin, 1994). In 1987, Hopper Specialty decided to purchase a computerized inventory-management system from NCR. The system in question was called, "Warehouse Manager," and it was installed in 1988. Several problems surfaced immediately after the system had been installed.

According to Hopper Specialty's representatives, the system never worked as it was supposed to. It displayed an assortment of problems such as extremely low response times, constant locking up of terminals, and corrupted data files. In 1993, more than 5 years after the system was installed, Hopper Specialty cancelled the contract with NCR and sued the company. They claimed that they had suffered a loss of $4.2 million in profits due to problems caused by the installation and use of Warehouse Manager. NCR's lawyers immediately asked that the lawsuit be dismissed on the grounds that it was filed too late. (New Mexico's statute of limitations for this type of lawsuit is only 4 years.)

Ethical considerations aside, NCR's lawyers had access to information and knowledge that allowed them to safely move for a case dismissal. The information to which we refer here regards New Mexico's statute of limitations and can be expressed by the assertion: "In New Mexico, a law suit, such as the one filed by Hopper Specialty, should be filed within at least 4 years after the alleged breach of contract occurs." The knowledge possessed by NCR's lawyers allowed them to build a link between information about the law, in this case the statute of limitations, and the likely consequence (information about the future) of grounding their defense on New Mexico's statute of limitations. This knowledge can be summarily expressed by the rule: "*If* we move for a case dismissal based on New Mexico's statute of limitations, *then* it is likely that the case will be quickly dismissed by the judge presiding the case."

Figure 4 depicts the relationship between data, information, and knowledge based on the case discussed above. The following printed or electronic documents store information that could be used by NCR's lawyers to defend their company in the lawsuit filed by Hopper:

- The lawsuit notification;
- The contract between NCR and Hopper;
- Warehouse Manager's documentation;
- A legal database of previous cases;
- Law books; and
- New Mexico's constitution.

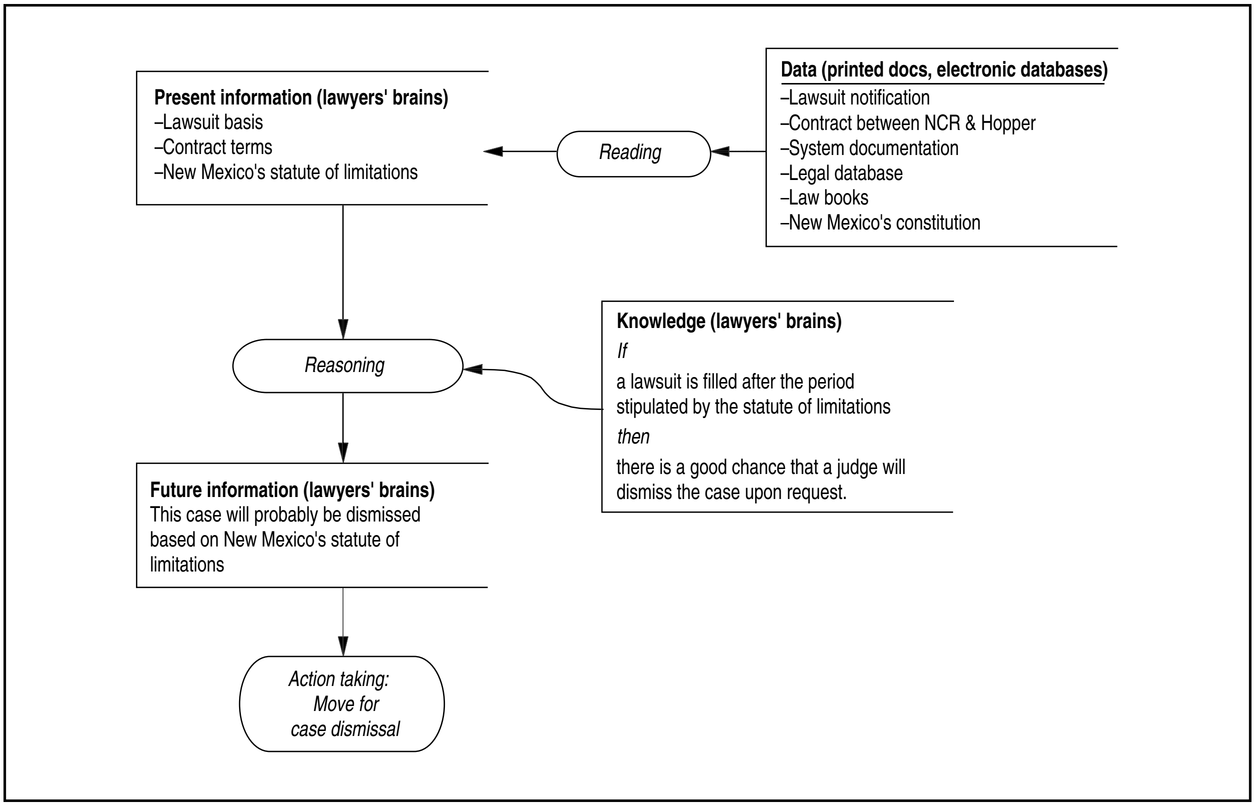


Figure 4. The Relationship Between Data, Information, and Knowledge.

In Figure 4, items are physical or electronic records (i.e., data first read by NCR's lawyers). Once these records were read, the lawyers could extract some pieces of relevant information about the present situation. Examples of such pieces of relevant information are the terms of the contract between NCR and Hopper and New Mexico's statute of limitations.

Present information can then be combined with knowledge linking the main goal — generic statute of limitations — and the likely consequences of not observing the stipulated lawsuit filing expiration date. This combination of knowledge and information allows for the prediction of the future with a certain degree of certainty, that is, the generation of "future information" or information about the future. In the case of NCR versus Hopper, this future information was the prediction that the presiding judge would dismiss the case based on New Mexico's statute of limitations. NCR's lawyers, therefore, took the appropriate action of moving for a case dismissal.

CHAPTER 3
THE INFODESIGN METHODOLOGY

Underlying Principles

InfoDesign's underlying principles are tailored to the redesign of *supply-chain* processes. The term "*supply chain*" is based on a simple categorization of processes according to the amount of knowledge transfer required during their execution. Processes can be categorized as *supply-chain* and *knowledge-intensive* processes. If we built a scale measuring the amount of knowledge transferred at execution time, these two types of processes are at different extremes. Supply-chain processes would be at the lower end of the scale. Knowledge-intensive processes would be at the high end (see Figure 5).

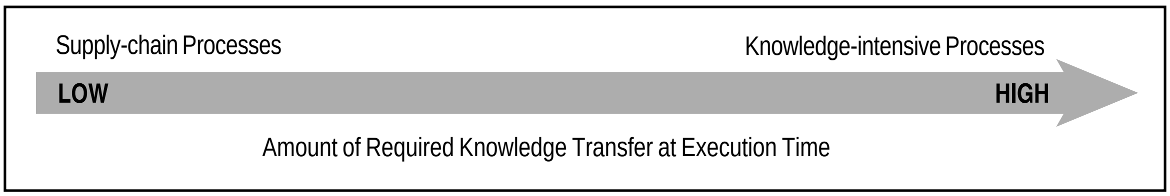


Figure 5. Types of Processes According to the Amount of Knowledge Transfer at Execution Time.

Examples of supply-chain and knowledge-intensive processes are provided in Table 1. In addition to the amount of knowledge transfer, supply-chain and knowledge-intensive processes can be differentiated based on their frequency and degree of standardization. Supply-chain processes are usually executed more frequently than knowledge-intensive processes. For example, an "order taking" process is usually executed several times a day (at least once for each product or service sold), while a "training" process takes place every once in a while (e.g., every quarter). Supply-chain processes are also usually more standardized than knowledge-intensive processes. For example, it is likely that there will be better defined procedures to execute a "production" process than to execute "technology transfer" processes. This is primarily due to the fact that knowledge-intensive processes are more "messy" and irregular than supply-chain processes.

Supply-chain and knowledge-intensive processes are closely related in that the latter are completed typically to ensure that the former are executed well and that they generate expected outcomes. For example, a "training" process may be executed to ensure that the "acquisition" process is executed according to regulations and in an optimal way.

Supply-chain Processes	Knowledge-intensive Processes
Order taking	Training
Acquisition	Technology Transfer
Production	Process Improvement
Delivery	Strategic Planning
Distribution	New Product Design

Table 1. Examples of Supply-Chain and Knowledge-Intensive Processes.

A methodology for process redesign is necessarily made up of guidelines that are followed by those who employ it. Since those guidelines should be defined for each step of the methodology, there are usually many of them, several of which may appear disconnected and coming out of nowhere. Given this, it is usually advisable to define key principles that are used as a basis for the creation of guidelines. The InfoDesign methodology is based on the seven key principles outlined below: (For simplicity, data, information, and knowledge are referred to by the letters "D," "I," and "K," respectively, in this discussion.)

The "Minimum Data Proportion" Principle

- Maximization of the I/D and K/D ratios in data exchanges of supply-chain processes leads to lower communication losses and, thus, higher process productivity.

For example, if a data exchange using a 20-field form (with approximately 400 kilobytes of data) could transfer the same amount of information and knowledge using a 5-field form (with approximately 100 kilobytes of data), then the 5-field form would lead to lower communication losses and higher process productivity. In this case, higher communication losses would not be due to telecommunication costs but to extra cognitive effort and likely mistakes caused by the need to filter relevant information and knowledge from meaningless data (Kock, 1999).

The "Maximum Information Proportion" Principle

- Maximization of the I/K ratio in data exchanges of supply-chain processes leads to lower communication losses and, thus, higher process productivity.

For example, if an employee who is responsible for a component activity of a supply-chain process needs to "learn" how to conduct that activity while executing it, more time would be spent communicating about the activity than if only discrete pieces of information were being exchanged (Kock and McQueen, 1998; Kock et al., 1997a).

The "Maximum Shared Knowledge" Principle

- Maximization of shared K among supply-chain process agents leads to lower communication losses and, thus, higher process productivity.

For example, if each member of a six-employee team, which is responsible for the execution of a supply-chain process, knows a great deal about what the others do, then their communication will become more efficient, and the productivity of the process, as a whole, will be increased (Kock, 1999a).

The "Minimum Data Transfer Points" Principle

- Minimization of the number of required data exchanges in supply-chain processes leads to lower communication losses and, thus, higher process productivity.

For example, if the number of data exchanges (happening by means of forms, memos, E-mails, etc.) in a supply-chain process could be reduced from 20 to 5 with no effect on the information and knowledge requirements of the process, then communication losses would be reduced and productivity increased.

The "Minimum Data Transfer Costs" Principle

- Minimization of the cost of data exchanges leads to lower overall supply-chain process costs and higher process productivity.

For example, if 10 data exchanges of approximately 1 megabyte each cost $100 because of the use of an expensive medium (e.g., a private mobile-phone network), then the adoption of a cheaper medium (e.g., the Internet) will reduce their costs. This will, in turn, lead to lower overall process costs and increased process productivity.

The "Quality versus Productivity" Principle

- If quality is compromised to gain productivity, productivity gains will not materialize in supply-chain processes.

For example, if an increase in productivity in a supply-chain process leads to a less desirable product, the demand for that product would go down. Thus the productivity increase would not contribute to bottom-line financial gains (Deming, 1986).

The "Continuous Improvement" Principle

- Organizational changes that take place outside the scope of supply-chain processes require the supply chain to be continually redesigned.

For example, even if the application of all the previous principles leads to an optimized supply-chain process today, it is likely that the process will not be optimal 6 months to 1 year from now. Therefore, measurement and review activities must be incorporated into supply-chain processes to force continuous and incremental revisions of the processes to cope with changes in the organizational environment surrounding the processes (Davenport, 1993; Deming, 1986; Hammer and Champy, 1993).

The principles discussed above provide a consistent and comprehensive framework upon which more specific guidelines for process redesign are based. Those guidelines are applied in the context of activities that make up the InfoDesign meta-process, which is discussed below.

InfoDesign at a Glance

InfoDesign is a methodology to guide the work of groups redesigning acquisition processes. One of its components is a group process (or meta-process). As a methodology, InfoDesign can be fully

defined as a set of activities, guidelines, and representation tools to be used by process redesign groups. It is suggested that group size should be between 3 to 25 participants who play the roles of group leader, facilitator, and ordinary members. The goal of the group is to identify an acquisition process where improvement opportunities exist and to propose changes that will translate those opportunities into practical improvement.

InfoDesign is made up of three main stages: process definition, analysis, and redesign. Each stage comprises interrelated activities. In order to define the guidelines and representation tools to be used in InfoDesign, it is important to identify the activities in each of the stages as well as the group roles involved. Group roles in InfoDesign are analogous to process functions in organizations. The activities involved in each of the stages are summarized below:

- *Process Definition (Definition Stage):*

  — Identify problems
  — Identify processes
  — Select a process for redesign

- *Process Analysis (Analysis Stage)*:

  — Model the process
  — Summarize performance information
  — Highlight opportunities for improvement

- *Process Redesign (Redesign Stage)*:

  — Search for suitable changes
  — Incorporate changes into the process

The illustration in Figure 6, which follows, is a simplification of the real meta-process. The goal of this illustration is to provide a clear, yet limited, view of InfoDesign as a whole. Loops and interactions with members outside the group are not represented, though these are likely to occur in real process redesign groups. For instance, while performing the activity "evaluate redesign feasibility," a group may decide that it must go back to the activity "search for suitable changes" due to the impossibility of implementing some of the proposed changes. Also, the facilitator of a group targeting a specific acquisition process in the IT Department of an organization may need information from the Finance Department during the stage "raise performance information."

Two permanent groups should be set up by an organization implementing InfoDesign in order to guarantee the success of process improvement groups — the *Process Improvement Committee* and the *Process Improvement Support Team*.

The *Process Improvement Committee* analyses process redesign proposals and, when necessary, coordinates and supports their implementation and standardization throughout the organization. The Process Improvement Committee members should have enough authority to coordinate the imple-

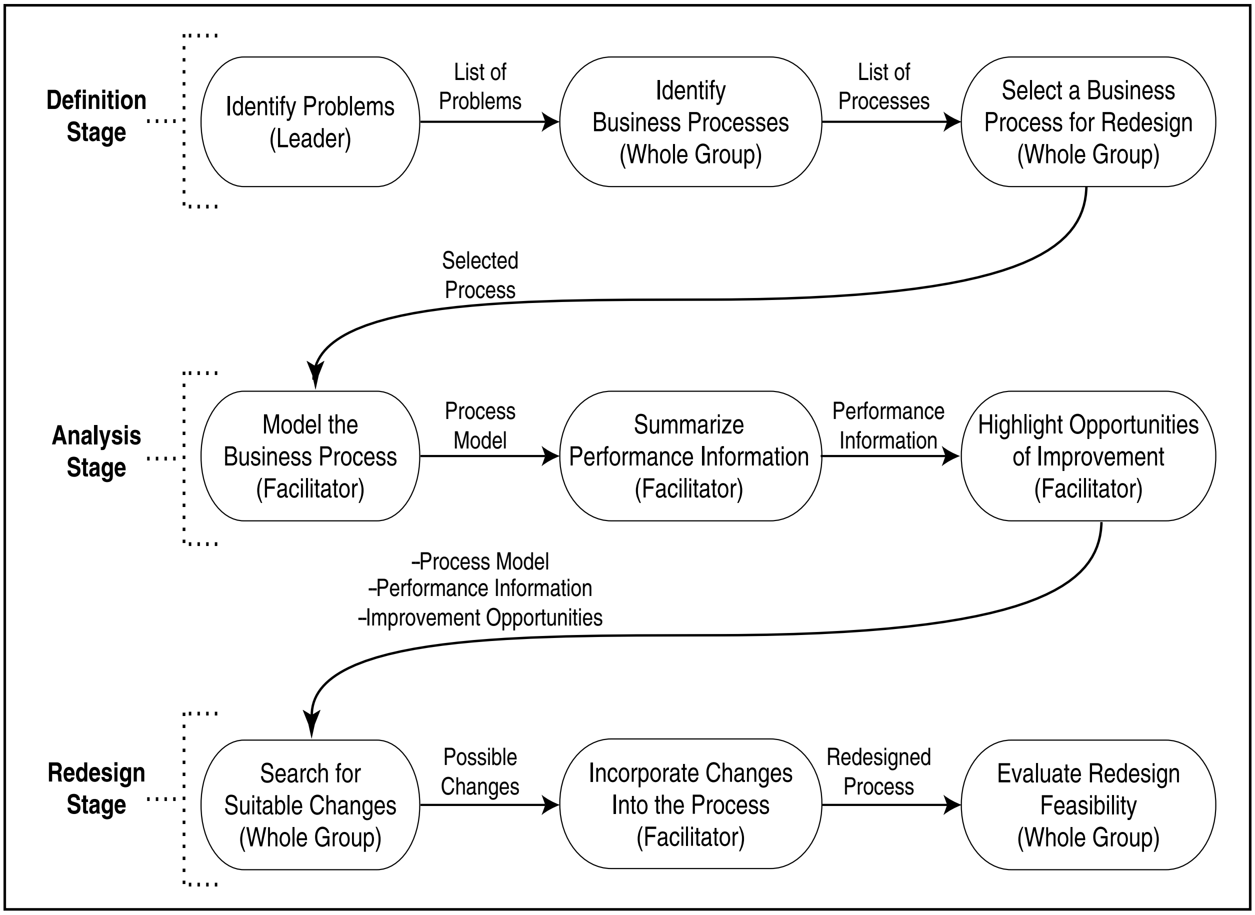


Figure 6. InfoDesign as a Set of Interrelated Activities.

mentation of strategic changes, such as those requiring large investments and organization-wide restructuring.

The *Process Improvement Support Team*'s main function is to provide process improvement groups with necessary methodological and technological support. It is also responsible for documenting, organizing, and providing public access to the information about process improvement initiatives in the organization (e.g., documents generated by previous process redesign groups).

The InfoDesign Group

InfoDesign comprises three group roles: leader, facilitator, and member. A process redesign group is initiated by a self-appointed leader, who should initially identify a set of problems related to an acquisition process to be tackled by the group. The group leader then invites other members to be part of the group and appoints one of these members as the group facilitator. The group leader should advise the Process Improvement Support Team that the group has been created, so the Process Improvement Support Team can support and document the group's evolution.

The InfoDesign Group Leader

The leader coordinates the activities of the group and interacts with the Process Improvement Support Team. The responsibilities of a group leader include:

- Scheduling meetings and making sure the necessary resources are available. Such resources may include, for instance, a room with an overhead projector or an electronic conferencing system (in the event the group will meet primarily electronically);

- Contacting group members and making sure they are able to attend the group meetings, either face-to-face or electronically; and

- Gathering and organizing the documentation generated by the group and, after the process redesign group has completed its work, supplying the Process Improvement Support Team with this documentation.

The InfoDesign Group Facilitator

The InfoDesign group facilitator plays two roles at the same time — a support role as well as a moderator role. This person is responsible for:

- Creating and maintaining a model of the process targeted for redesign, and

- Summarizing performance information about the process and highlighting opportunities for improvement.

To meet these responsibilities, the facilitator must have a thorough understanding of InfoDesign's guidelines and representation tools. The facilitator does not make decisions alone on the adoption of specific changes; this is a prerogative of the InfoDesign group as a whole and must be achieved by consensus.

The InfoDesign Group Member

The other members of the group (i.e., the "ordinary" members) will provide their inputs throughout the group discussion in a "low-cost" participation manner. As in most types of moderated group discussions, the majority of the burdens of coordinating communication, compiling member contributions, and documenting group decisions are on the leader and the facilitator. One person can play more than one role in the group. For example, one person can be the group leader, the facilitator, and provide inputs as a group member.

General Guidelines for InfoDesign

Guidelines are "how-to" rules that can refer to the InfoDesign meta-process, as a whole, or its component activities. Guidelines follow that relate to the InfoDesign meta-process as a whole; they are not specific to a particular activity.

- The process improvement group should develop a redesign proposal in a limited amount of time, ideally in no more than 8 weeks. Previous research shows that an acceptable "average" time is 3 weeks (Kock and McQueen, 1995).

- The stages a process redesign group goes through should be documented. The leader is primarily responsible for this documentation, which is essential to building historical documentation about organizational process redesign initiatives. This information can be used for many purposes, such as a basis for future process redesign groups and as evidence of the organization's commitment to improving process quality in quality accreditation audits. For example, the organization may use process improvement group documentation in ISO-9000 certification audits to show that exemplary procedures for dealing with "nonconformities" were followed (Kock and McQueen, 1997).

- Each of the group meetings should conclude with a link to the next meeting. A meeting where the activities "identify problems" and "identify processes" are accomplished should end with a preliminary selection of a process to be redesigned. This preliminary selection works as a link to the next meeting, where the first activity will be "select a process for redesign." These "links" between meetings are aimed at improving group focus.

- The facilitator should not try to enforce the group process (i.e., InfoDesign) described in this document. Instead, this person should induce it in a "transparent" way. In most cases, this will occur almost naturally as the facilitator is responsible for several of the key activities of the process redesign group.

InfoDesign in Detail: Activities, Guidelines, and Representation Tools

The following subsections provide a discussion of each of the activities in InfoDesign, including guidelines and representation tools used. (Subsection titles are formed by the main stage, which is followed by a colon and the name of the activity.)

Definition Stage: Identify Problems

In the definition stage, the first group activity is to identify problems. As discussed before, the person who first brings the problems up for discussion is a self-appointed group leader. Virtually anyone can be a group leader, which helps spread the responsibility for the innovation over the organization and reduces the innovation's reliance on managers. This broadens the process improvement's scope of application as the number of managers in one organization is usually smaller than that of line employees.

In some forms of process improvement where the improvement is gradual and accomplished by permanent groups (e.g., quality circles), the search for improvement does not necessarily rely on the previous identification of problems. In these cases the improvement is routinely sought based on the assumption that every process can always be improved in one way or another. However, research shows that the identification of problems as sources of discontent within the organization is a success factor in process improvement (Hall et al., 1993).

The identification of problems fosters interest in process improvement among organization members and, at the same time, gives them an idea of what is to be achieved with the improvement. The identification of problems, though, is only the beginning of InfoDesign. The main outcome of InfoDesign is process improvement, not problem solving. The identification of problems is an intermediate step that leads to the selection of a process for improvement (Harrington, 1991).

Guidelines

- Generate a list of interrelated problems, and submit it to the process improvement group so mistakes and omissions can be corrected. The group leader should prepare the preliminary version of the list. This is the first step in the formation of the group.

- Concurrently with the generation of the list mentioned above, the leader should invite prospective group members. Listing problems and inviting group members are two interrelated tasks. Expect little involvement from group members who have no interest in the problems initially listed.

- Problems in the list should be at least intuitively related. A list of problems that is excessively broad and involves several different areas of an organization, for example, leads to the identification of several processes for redesign. This is likely to disperse the focus of the process improvement group.

- Problems should be approached in a very clear and open way. There should be no fear of disclosing discontent with the actual situation. Poor identification of problems (e.g., certain problems are not discussed because they may upset some individuals) leads to poor process redesign (Deming, 1986; Kock and Tomelin, 1996).

Definition Stage: Identify Processes

Once a list of interrelated problems is identified, the next step is to identify the processes associated with those problems. At this point it may be found that some processes are clearly defined, while others are not (Wastell et al., 1994). For instance, it may be found that several problems are associated with the activity "inform bidders about the outcomes of the review of bids," which was not previously seen as part of a set of interrelated activities.

Guidelines

- A process improvement group should not try to build process models in this activity. Instead, the interrelated activities that are perceived by the group as the *causes* of problems should be listed using one or a few words. For example, the acquisition-related problems listed may be "late invoices," "customer complaints about invoice complexity," "inaccurate invoices," and "late payment." As these are all related to the process of issuing invoices, the

processes can be simply described in this activity as “invoicing.” Later, in the second stage of InfoDesign — the process analysis stage — the selected process or processes will be analyzed in more detail.

- A process improvement group should not expect to identify one process for each problem or vice-versa. The relationship between problems and processes may be a “many-to-many” one. That is, several processes can cause one problem; and, conversely, several problems can be caused by one process. Thus, even though the initial list of problems may have only “one” problem, it may help in the identification of several processes for improvement.

Definition Stage: Select a Process for Redesign

This activity is a conclusion of the work started in the previous activity, “identify processes.” Here, one of the processes identified in that activity will be chosen for redesign.

When several processes are identified, group members may want to select more than one process for improvement. This is frequently the case when there are no clear boundaries between processes within the organization. However, as the number of selected processes increases, so does the complexity in the next stage, “process analysis.” An additional drawback of the selection of many processes for redesign is the high number of changes likely to be proposed by the group. A high number of processes selected for redesign may hinder the process improvement group from focusing on one specific process that needs urgent attention. It may also reduce the level of care given to the analysis and redesign of each individual process.

Guidelines

- The process improvement group should strive to select as few processes as possible. Ideally, only one process should be selected.

- The process that is associated with the most critical problems should be given priority in the selection.

- After applying the preceding guidelines, the process that is associated with the highest number of problems should be given priority in the selection.

Analysis Stage: Model the Process

In this activity the process considered for improvement by the process improvement group is modeled using two process representation tools. The goal of this activity is to understand the relationships between process activities and to obtain a clear view of the process as a whole.

Representation Tool: Activity Table

The activity table provides a first step in the process modeling activity and sets the stage for the development of the InfoDesign diagram, which is discussed in the next section. An example of an activity table, based on a software development acquisition process, is provided in Figure 7. A typical activity table has five columns. The first column, on the left, shows the number of each activity. The other four columns are titled, "What," "When," "Who," and "How." In the "What" column, each activity is briefly described by a transitive verb in the infinitive form followed by its object. The "When" column indicates when the activity is conducted — this is usually done by specifying what activity or activities immediately precede the current activity. The "Who" column indicates who performs the activity — usually by means of an organizational function (e.g., technical lead) or a group within the organization (e.g., contracts department). The "How" column is a memo-type column where a description of how the activity is conducted is provided — usually specific tools or artifacts used in the activity are indicated in this column (e.g., automated proposal preparation system).

#	What	When	Who	How
1	Receive Request for Proposal (RFP)	Beginning of process	Contracts Manager	Using Secure Workflow process from customers' Contracts Officer
2	Announce RFP	After 1	Contracts Manager	Using E-mail and highlighting suspense date (due date) requested by customer
3	Prepare proposal	After 2	Technical Lead, Contracts Manager, Finance and Accounting	Using automated proposal preparation system
4	Prepare Basis of Estimate (BOE)	After 2	Technical Lead	Using historical data and BOE template (MS Word)
…	…	…	…	…

Figure 7. Example of Activity Table.

Developing an activity table is a preliminary step that may or may not be taken by an InfoDesign group. The goal is to give the group a basic idea of what the process looks like using a simple text-based, work-flow representation. The next step is the development of an InfoDesign diagram to show how information and knowledge flow and are stored in the process. Assuming that information and knowledge flow and they are stored by means of data items, data flows are not represented explicitly in InfoDesign diagrams.

Representation Tool: InfoDesign Diagram

An InfoDesign diagram is made up of a combination of the four symbols shown in Figure 8. The "process agent" symbol represents an organizational function that plays a role in an acquisition process. The "process activity" symbol represents an activity that makes up an acquisition process. The "IK flow" symbol represents the flow of information and/or knowledge in an acquisition process. Finally, the "IK store" symbol represents an information and/or knowledge "store" of an acquisition process. A "store" can be any repository that stores information and knowledge through data in a temporary or permanent way.

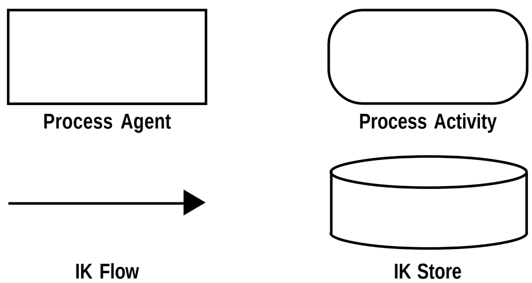


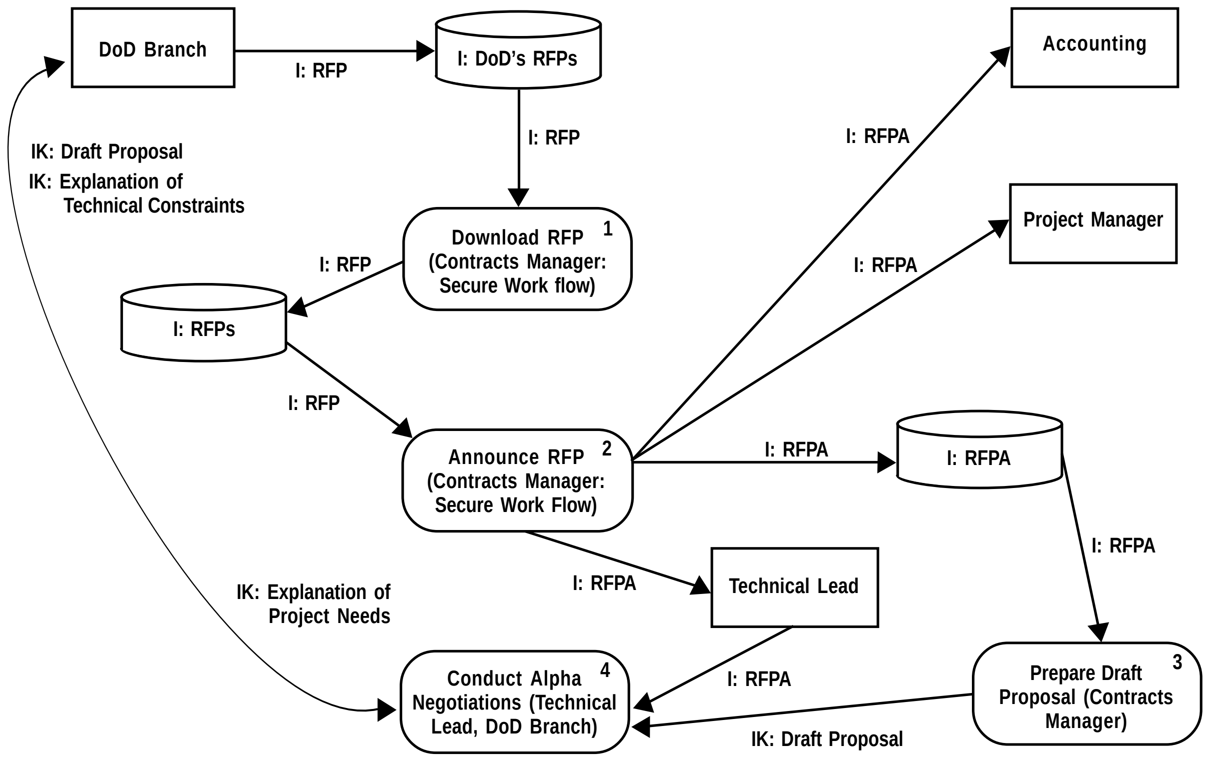
Figure 8. InfoDesign Diagram Symbols.
(IK = Information and Knowledge)

A process agent usually carries out one or more activities in an acquisition process. Some activities may be carried out without human intervention (i.e., automatically) and still be represented in an InfoDesign diagram using "process activity" symbols. Activities can be "exploded" into other activities in "lower-level" InfoDesign diagrams. That is, an acquisition process can be represented by several InfoDesign diagrams, each modeling the acquisition process at different levels of detail. The highest-level InfoDesign diagram is the level 1 InfoDesign diagram. In a level 1 InfoDesign diagram, activities are numbered from 1 to N, N being the number of activities represented in an InfoDesign diagram. These numbers should indicate the sequence of execution of activities in an acquisition process in an approximate way.

If an acquisition process activity seems too complex to be understood without further decomposition, then it can be "exploded" into a separate InfoDesign diagram. Let's assume that activity 2 of an acquisition process is very complex. This activity can be "exploded" into a level 2 InfoDesign diagram, where the component activities will be numbered 2.1, 2.2, 2.3, and so on. If one of the activities of this level 2 InfoDesign diagram (say activity 2.3) is too complex and needs to be "exploded," a level 3 InfoDesign diagram can be created. The component activities of level 3 will be numbered 2.3.1, 2.3.2, 2.3.3, etc.

The InfoDesign diagram incorporates all the elements of the activity table, as well as other elements that indicate how information and knowledge are stored and how they flow in an acquisition

process. An example of InfoDesign diagram, based on a software development acquisition process, is provided in Figure 9. Only part of the process is shown in Figure 9; the emphasis is on the communication of a Request for Proposals (RFPs) from a Department of Defense (DoD) branch to a software development contractor[2] and the internal activities at the contractor that immediately follow this communication.



Notes:
- Alpha Negotiations: Initial negotiations between DoD Branch and Technical Lead to define the budget for the project
- DoD: U.S. Department of Defense
- RFP: Request for Proposal
- RFPA: RFP Announcement
- Secure Workforce: DoD Branch application that allows selective access to RFPs

Figure 9. Example of InfoDesign Diagram.
(IK = Information and Knowledge)

Guidelines

- The description within a "process activity" symbol should be as brief as possible and begin with a verb in the infinitive form (e.g., download RFP, announce RFP, prepare draft proposal, conduct Alpha Negotiations, drill a computer card, load a batch of parts onto a truck, etc.).

[2]The diagram is based on a Computer Sciences Corporation (CSC) process redesign project; one of the authors was involved in this project.

- An InfoDesign diagram should have a limited number of symbols so it is not too complex for someone who did not participate in its development. Studies on human cognition limitations provide the basis for establishing an optimum number of symbols in process modeling diagrams (Miller, 1956). These studies suggest that this number should be between 5 and 9 symbols (i.e., 7 plus or minus 2). When a process cannot be represented with less than 14 symbols (i.e., twice the optimum average) due to its complexity, some of the activities should be “exploded” into lower-level InfoDesign diagrams (Pressman, 1987).

- Trivial artifacts should not be described in “process activities” (e.g., pen and paper, telephone, etc.). A rule of thumb is to describe only artifacts that are specific to an activity (or type of activity) and without which the activity could not be carried out (e.g., Secure Work Flow (a computer system shown in Figure 9), lathe, computerized drill, cheese processor, inventory control system, etc.). An artifact is specific to an activity or type of activity whenever it has been designed to support only that activity or type of activity.

- When modeling a process, the facilitator should not be afraid of adding handwritten notes and marks to the diagram if they are needed to clarify certain points. The emphasis should be on using the graphical tool in an effective way to convey information and knowledge that will allow the group to redesign the process rather than in a “rule-abiding” way. Keep the chart as neat and tidy as possible by strictly sticking with the charting symbolism.

Analysis Stage: Summarize Performance Information

In this activity, information about the performance of the process is summarized for the InfoDesign group. This information should gravitate around two main process attributes — quality and productivity. A direct measure of process quality is customer satisfaction, so the best way to evaluate it is to obtain information on how the customers of the process perceive its outputs. The customers of an acquisition process are those inside and outside the organization who receive outputs generated by activities of the process. Such outputs may include budgets, proposals, specifications, project plans, etc. For example, a well-prepared, high-quality budget is a budget that not only meets the requirements of the project at the lowest possible cost for the buyer but also does not fall below the specified requirements. Similarly, a budget that is lower than is necessary to meet all the requirements of the project under bid is likely to lead to the delivery of low-quality outputs or to the delivery of no outputs at all.

Productivity is traditionally measured by the ratio outputs/inputs (Misterek et al., 1992). This means that an acquisition process that employs 10 people and completes 2 acquisition “units” (i.e., an arbitrary metric used to count acquisitions) per month may be said to have a productivity of 2/10 = 0.2 acquisition units per month per employee. If the same process is redesigned so it can complete the same 2 acquisition units per month but, now, with 5 employees, then its productivity will be 2/5 = 0.4 acquisition units per month per employee. That is 100 percent higher than before.

A better way to measure process productivity is by considering the ratio (production capacity)/(production costs). This offers two advantages against the (input/output) approach discussed above:

- It considers the *costs* of the inputs to the process and not their *quantity*; and

- It takes into consideration the *capacity* of a process and not its *realization*.

Even when its cost is reduced, the quantity of each input may remain the same due to process improvement. For example, an acquisition process may benefit from a smarter use of less expensive information technologies, whether the number of acquisition units is reduced or not. This is why the analysis of cost is critical to productivity measurement as opposed to the approach of counting the number of inputs. Yet, this approach implies a higher measurement complexity as costs can vary considerably with time.

The measurement of the production capacity for a process implies forecasting. To say that an acquisition process has a production capacity of 300 acquisition units a year means that the acquisition process *can* produce that figure on average but not that it is the real average output. Since production in real contexts depends on consumption expectancy, which in turn is based on the buyer's budget and needs, the simple measure of outputs can lead to wrong assumptions about productivity. This risk is suppressed when productivity assessment is based on production capacity (Goldratt and Fox, 1986). Complexity here is, again, increased by the need to estimate process output capacity based on historical figures and resource capacity of specific units. However, in many cases this may be easier than relying on real numbers with measurements that are severely hampered by the added cost of extensions in the accounting system of the organization (Mark, 1984).

So, the analysis of productivity should be based on estimates of production capacity and costs rather than on outputs and inputs. While likely to add complexity to measurement, this is useful because it draws a line between productivity and quality assessment. The output/input approach disregards the fact that quality improvement is bound to generate more consumption and, consequently, promote an increase in output (Deming, 1986). By connecting productivity with the actual outputs produced by a process, one could mistake quality for productivity improvement. This is particularly true when a surge in demand, due to higher quality, is simply supported by excess capacity, not augmented productivity.

<u>Guidelines</u>

- In the first activity of InfoDesign — the one aimed at identifying problems — the group should have gathered information on process customer complaints. In this activity, the facilitator should try to find quantitative data associated with those complaints and should try, for example, to identify, by means of quantitative measures, the problems customers see as the most critical and as occurring the most often.

- In this activity, the facilitator should not be concerned with *generating* performance information. The facilitator should, instead, focus on summarizing *existing* information about the process performance. This information may come from areas of the organization that are not

represented in the process improvement group. Generating performance information may take too long and, therefore, make the process improvement group lose momentum. A lack of process performance information, identified by a group in its analysis stage, may become a problem to be tackled by a different process improvement group.

Analysis Stage: Highlight Improvement Opportunities

Based on performance information raised in the previous activity, the facilitator highlights opportunities for improvement in this activity. This is helpful in leading the InfoDesign group towards the discussion of concrete changes to improve the process.

Guideline

The facilitator should highlight process improvement opportunities by proposing changes in the process to be discussed by the group. These changes should be based on the information gathered during the two previous activities, namely, "model the process" and "raise performance evaluation." They should also follow the guidelines "search for suitable changes" discussed in the next activity.

Redesign Stage: Search for Suitable Changes

In this activity group members propose suitable changes in the process so improvements of quality and productivity can be achieved. The literature on process improvement provides several guidelines for making improvements. These guidelines can help process improvement group members formulate their redesign proposals.

Guidelines

Harrington (1991) provides several guidelines for process improvement based on general principles such as process and activity simplification, bureaucracy elimination, standardization, and technology utilization. Hall et al. (1993) and Venkatraman (1994) propose guidelines for redesigning processes according to improvement dimensions and scope levels. Guha et al. (1993) and Wastell et al. (1994) present some process improvement guidelines as part of specific process redesign programs. Dingle (1994) and Caron et al. (1994) draw guidelines from the analysis of process reengineering cases. Kock (1999a) summarizes these guidelines and proposes several of his own, based on the analysis of face-to-face and computer-mediated process improvement groups. The guidelines below build on this body of normative work; they are organized around the seven principles discussed earlier in this chapter.

- **Maximize the I/D (information/data) and K/D (knowledge/data) ratios in data exchanges.** This can be achieved by analyzing each data exchange (e.g., form, memo, etc.) and eliminating data components that are not used (i.e., not processed). For example, a project requirements form of a call for proposals may contain 20 different fields, but only 5 of those fields are actually used by those who are going to prepare a draft proposal. In this case, the number of fields on the form should be reduced to 5, which are the fields that are actually used.

- **Maximize the I/K (information/knowledge) ratio in routine data exchanges.** This can be achieved by eliminating the knowledge content in routine data exchanges and creating special processes. These processes are external and ancillary to the acquisition process being considered, and their main goal is knowledge sharing. These special processes will likely limit the need for the exchange of knowledge content in routine data exchanges, which has been shown to negatively affect process productivity (Kock and McQueen, 1998).

- **Maximize shared K (knowledge) among processes.** As discussed above, this can be achieved by creating special processes whose main goal is knowledge sharing. One type of process that has been shown to be conducive to knowledge sharing is "process improvement" (Kock, 1999a). Thus, using a methodology, such as InfoDesign, is likely to increase the amount of knowledge that process agents, who worked as process improvement teams, share about the process they participated in.

- **Minimize the number of required data exchanges.** This can be achieved by eliminating duplication of information and reducing information flow, control, and the number of contact points in the process.

  — *Eliminating duplication of information* is particularly important in static repositories (e.g., a database of suppliers) as opposed to dynamic repositories (e.g., a supplier data entry form) because the former hold information on a more permanent basis. Duplication of information in different static repositories often creates inconsistency problems, which may have a negative impact on productivity and quality and lead to unnecessary exchanges of data in acquisition processes.
  — *Reducing information flow* is key to minimizing the number of required data exchanges since data exchanges take place primarily so information can be transferred, usually between people. Information flow reduction can be achieved by selecting the information that is important in acquisition processes and eliminating the rest. Information flow can also be reduced by effectively using group support and database management systems. Thus, information can flow across several hierarchical levels without the need for filtering and "poligonation" (i.e., information that needs to go from individual A to individual B, first going to one or more individuals who simply forward the information to the next person). (See Kock, 1999a.)
  — *Reducing control* is important because control activities lead to unnecessary exchanges of data. Moreover, while some control activities are crucial to prevent major problems from happening, others are not; and they add little or no value to customers. The latter are often designed to prevent problems from happening as a result of human mistakes. In several cases, however, control itself fosters neglect and can have a negative impact on productivity. Additionally, some types of control, such as those aimed at preventing fraud, may prove to be more costly than no control at all.
  — Finally, *reducing the number of contact points* in an acquisition process is likely to reduce the number of required data exchanges because many contact points include data exchanges. Contact points can be defined as points where there is interaction among two or more people. Contact points generate delays and inconsistencies and, when in excess, lead to

process customer perplexity and dissatisfaction. Additionally, it is much easier to monitor customer perceptions in situations where there are a small number of contact points. This makes it easier to improve process quality.

- **Minimize the cost of data exchanges.** There are a number of different ways this can be achieved through the smart implementation of information technologies. From a conceptual perspective, however, one of the key ways this can be achieved is by fostering asynchronous communication. When people exchange information or knowledge, they can do it synchronously (i.e., interacting at the same time) or asynchronously (i.e., interacting at different times). One example of synchronous communication is a telephone conversation. If the conversation takes place via E-mail, it then becomes an example of asynchronous communication. It has been observed, especially in formal business interaction, that asynchronous communication is more efficient almost always. On the other hand, synchronous communication often leads to wasted time (e.g., waiting for the other person to be found), and communication tends to be less objective. Asynchronous communication can be implemented with simple artifacts such as in-boxes and out-boxes, fax trays, and billboards. These artifacts work as dynamic information repositories.

- **Maximize quality.** The "quality versus productivity" principle argues that, if quality is compromised so productivity gains can be achieved, productivity gains will not materialize. The focus of the process redesign guidelines discussed so far has been on the increase of process productivity by focusing on data, information, and knowledge. This guideline, "maximize quality," is a "moderating" guideline in that it moderates the application of the other guidelines. The application of the "maximize quality" guideline should begin with a question during the application of each of the previous guidelines in a real acquisition process. Ask if the resulting process change is going to have a negative impact on quality. If it is, then the implementation of the process change under consideration should be reconsidered and, if necessary, abandoned.

- **Incorporate "continuous improvement" activities into the process.** The "continuous improvement" principle argues that organizational changes that take place outside processes require the continuous redesign of processes. The process redesign guidelines discussed here are aimed at discrete or "one-shot" process improvement. Nevertheless, continuous improvement is also necessary (Kock, 1999a) to both refine the "one-shot" changes resulting from an InfoDesign project and allow for small and incremental process changes to take place over time in response to changes that take place outside the process. This can be achieved by incorporating three types of activities into the new process: (1) process performance measurement activities, (2) process performance review activities, and (3) process revision activities. The frequency of these activities should be lower than that of the process itself. For example, if an acquisition process is completed every week, continuous improvement activities could be completed every quarter.

At this point, it is important to stress that process improvement group members should not be concerned about the feasibility of their redesign proposals. This concern will only limit the innovativeness of the redesign and, therefore, its effectiveness. Redesign feasibility analysis will be carried out at a later point in an activity included especially for this purpose.

Redesign Stage: Incorporate Changes into the Process

In this activity, the facilitator should incorporate the changes proposed by the group into the process models and respective written descriptions. The models of the new process provide feedback to the group so proposed changes can be discussed and refined before they are put into practice.

Guideline

At this point, the facilitator should try to state who would be responsible for implementing the proposed changes in the process. If such changes need involvement from higher management levels, this should be clearly stated. Such involvement may be needed, for example, for investment approvals and certain changes in the organizational structure.

Redesign Stage: Evaluate Redesign Feasibility

This is the last conceptual activity of InfoDesign, and the final product is a new process to be implemented with the support of information technologies. In this activity the group members should discuss the feasibility of the changes proposed to the process so far and, if necessary, modify them to adapt those changes to the reality of the organization.

Subsequent Stages: Implement and Refine Redesign

The next stages are the initial implementation of the changes and their refinement so they can be used in a routine way. The group can proceed on its own to these stages, provided that no involvement from higher management levels is necessary to implement the changes. For example, if the group has enough authority to approve and support the changes proposed and the resources to carry this implementation out, the group can proceed to process change implementation right away. If the proceeding is not the case, the group should submit the change proposal to those who are in a position to have it implemented. Ideally, this should be done through the Process Improvement Committee, which is the committee responsible for the evaluation of redesign proposals and coordination of their implementation.

CHAPTER 4
THE NEED FOR A SHIFT IN REDESIGN FOCUS

A Brief Historical Review of Business Process Redesign

As discussed previously, business processes are sets of interrelated activities that are performed to achieve a business goal. Business process redesign dates back to the early 1900s, when Frederick Taylor (1911) published *The Principles of Scientific Management*. The scientific management movement strongly influenced process redesign ideas and approaches throughout the Second Industrial Revolution (1850-1950). During this period, business process redesign was primarily concerned with productivity (i.e., efficiency) improvement in manufacturing plants.

The work of Elton Mayo in the 1930s and others, such as McGregor, Maslow, and Herzberg, represented the emergence of the "humanist" school of management, which tried to shift the focus of organizational development from "business processes" to "people." While these management thinkers succeeded in doing so during the mid 1900s, business process redesign was far from "dead." The work of the "humanists" set the stage for the emergence of what many saw as a more "humane" business process-redesign school of thought. This new school of thought, generally known as total quality management, not only succeeded scientific management as a business process-based method but also represented a shift in focus from productivity to quality in the improvement of business processes. Total quality management began in Japan after the World War II. It was largely due to the work of William Deming and Joseph Juran and is widely credited as having propelled Japan to economic superpower status (Bergner, 1991; Chapman, 1991; Deming, 1986; Juran, 1989; Walton, 1989). In the 1980s it became widely practiced in the U.S. and other Western capitalistic countries. As with scientific management, its primary focus is the improvement of manufacturing operations.

In the early 1990s, business process reengineering replaced total quality management as the predominant school of thought regarding business process redesign. Michael Hammer and Thomas Davenport independently developed business process reengineering as, respectively, a better alternative (Hammer's version) and a complement (Davenport's version) to total quality management. Total quality management's primary goal is quality improvement, not productivity. With this in mind, they based their work on the premise that incremental gains in productivity obtained by implementing total quality management were insufficient for organizations coping with an accelerated rate of change fostered by information technologies (Davenport, 1993; 1993a; Davenport and Short, 1990; Hammer, 1990; Hammer and Champy, 1993). Differently from scientific management and total quality management, business process reengineering was presented as a method for the improvement of services as well as manufacturing operations.

Current Business Process Redesign Practices: A Rehash of Old Methods?

An analysis of the business process redesign practices throughout the 100-year period, from the development of scientific management to the emergence of business process reengineering, suggests an interesting, perhaps cyclic, pattern. Even though processes have changed significantly since

Frederick Taylor's times, the business process redesign practices employed then seem very similar to those of the 1990s (Kock, 1999a; Kock and McQueen, 1996; Waring, 1991).

The scientific management method consisted of breaking down a business process into component activities, for which a pictorial as well as a quantitative model was generated. The pictorial model depicted the execution flow of the activities and the associated motions, whereas the quantitative model included information about physical distances associated with motions and the times needed to perform each of the activities. Taylor showed that managers could empirically devise optimal (or quasi-optimal) business process configurations that could, then, be standardized through financial incentives to workers (Taylor, 1885; 1911).

The total quality management movement broke away from the productivity-only orientation of scientific management by emphasizing business process quality as the main goal of organizational development. One difficulty faced by the quality movement stems from the fact that "quality" is primarily a gauge of customer satisfaction and, thus, difficult to be measured. This may explain the gradual but steady emphasis on quality "process" standardization, which is also known as quality "systems" standardization. Total quality management gradually became a movement dominated by quality process (or system) standards, such as the influential ISO-9000 set of quality standards (Arnold, 1994). As such, the view that "quality companies" were those that complied with quality process standards became increasingly widespread. Many view this as having pushed total quality management in a wrong direction and into the hands of bureaucrats who specialized in quality standards implementation and certification.

The dissatisfaction created by the "bureaucratization" of total quality management and its alleged small and incremental impact on the "bottom-line" of the companies that implemented it (Hammer and Champy, 1993) set the stage for the emergence of business process reengineering. Many argue that business process reengineering is a "modernized" version of scientific management (Earl, 1994; Kock and McQueen, 1996; Rigby, 1993; Waring, 1991). The popularity of reengineering reached its peak by the mid-1990s and has since slumped due to a number of reported failures. James Champy, a pioneer of reengineering, argued that 70 percent of all reengineering projects failed to achieve their goals (Champy, 1995). In spite of this, reengineering created renewed interest in business process redesign, making it the most widely practiced form of organizational development in the Year 2000. Business process redesign in the New Millennium is usually conducted in conjunction with the implementation of enterprise systems and e-business applications (Biggs, 2000; Davenport, 2000; Hammer, 2000).

Current Focus on Activity Flows and Associated Problems

Unlike the "heyday" of scientific management, when business process improvement meant "materials-flow" improvement, information is what flows the most in business processes today. As pointed out by Drucker (1993): "In 1880, about 9 out of 10 workers made and moved things; today, that is down to one out of five. The other four out of five are knowledge people or service workers." A study by Kock and McQueen (1996) shows that, even in manufacturing organizations, approximately 80 percent of what flows in business processes is information, while the other 20 percent is made up of

materials. In service organizations, this ratio is usually very close to 100 percent to 0 percent. These figures seem to confirm the once visionary claims that "we are living in an information society" (Toffler, 1991) and that organizations have become "information organizations" (Drucker, 1989). The high proportion of information flow is also consistent with the widespread use of information technologies in organizations and its increasing importance in the improvement of business processes.

Paradoxically though, most of today's business process redesign practices focus on the analysis of business processes as sets of interrelated activities, and little attention is paid to the analysis of the information flow in business processes. The most widely adopted normative approaches for business process redesign embody general guidelines that place no special emphasis on the redesign of the information flow. Thus, the information-intensive nature of business processes is discarded (Kock and McQueen, 1996). This is also true for the DoD, where the IDEFO approach for business process redesign (Ang and Gay, 1993) has been chosen as the official approach. The IDEFO approach is based on activity flow and is by far the most widely used (Dean et al, 1995). One widely used activity-flow approach proposed by Harrington (1991, p. 108) goes as far as stating that: "As a rule [information flow diagrams] are of more interest to computer programmers and automated systems analysts than to managers and employees charting business activities." (See also Harrington et al., 1998.) While this opinion is obviously at odds with the notion that information processing is the main goal of business processes (Galbraith, 1977), it is very much in line with the original claims of reengineering (Hammer and Champy, 1993) and most of the current business process redesign practice.

CHAPTER 5
VALIDATING INFODESIGN THROUGH AN ACTION RESEARCH STUDY

Research Hypothesis and Its Negative Form

Given the discussion so far in this report, it is reasonable to expect that business process redesign approaches that focus on the flow of information will be more effective. Thus, they are preferred by practitioners over those based on the traditional activity-flow view of processes, simply because they will provide a better understanding of the business processes targeted and a clearer view of how process changes should be implemented. This expectation, which is at the source of the development of the InfoDesign methodology, is formalized in hypothesis H1a below:

> H1a: Business process redesign practitioners perceive approaches that focus on information flow as more effective than approaches that focus on activity flow.

H1b (negative form of H1a that was developed for hypothesis testing purposes):

> H1b (negative form of H1a): Business process redesign practitioners perceive approaches that focus on information flow as either less effective than, or presenting the same effectiveness as, approaches that focus on activity flow.

By providing both positive and negative forms of the hypothesis, Popper's (1992) "falsifiability criterion" for hypotheses corroboration could be used in this study, which adds robustness to the study's findings. The falsifiability criterion is explained in more detail in the next section.

Hypothesis H1a and its negative form, H1b, were tested through an action research study of a business process redesign project involving the DoD and Computer Sciences Corporation, a leading software provider for the defense sector. The project also involved employees from Lockheed Martin, a regular business partner of the Computer Sciences Corporation.

Research Approach Employed: Action Research

The research approach employed was action research (Checkland, 1991; Rapoport, 1970; Susman and Evered, 1978; Winter, 1989); it was adapted for the specific context of business and information technology research (Baskerville, 1997; Lau, 1997; Wood-Harper, 1985). One of the main characteristics of organizational action research is that the researcher, or research team, applies "positive" intervention to the participating organization while collecting research data (Elden and Chisholm, 1993; Francis, 1991; Peters and Robinson, 1984). In this research project, the researcher (one of the principal investigators) provided business process improvement training and facilitation to the members of a business process redesign team involving employees from the DoD and Computer Sciences

Corporation. The facilitation was solely methodological (i.e., no specific process redesign suggestions were offered), and it was also “methodologically neutral.” This neutrality prevented biased perceptions of the redesign approaches used.

Action research was employed for two reasons. First, action research places the researcher in the “middle of the action,” allowing close examination of real-world business situations in their full complexity. Therefore, it is a particularly useful research approach for the study of “new” business topics and hypotheses, such as those addressed by this research study. The second reason stems from the use of Popper’s “falsifiability criterion.” This criterion states that a researcher should prove a hypothesis not only by looking for evidence that supports it but also by looking for evidence suggesting an exception to the hypothesis (i.e., evidence supporting the negative version of the original hypothesis). Therefore, based on the “negation” of H1a in the previous section, H1b was formulated. According to Popper’s epistemology (i.e., Popper’s accepted rules for creation of valid knowledge), the absence of contradictory evidence becomes a strong corroboration of the original hypothesis (Popper, 1992). In action research, the researcher is an “insider” as opposed to a “removed observer” and, thus, has access to a broader body of evidence than in other research approaches (e.g., case research, survey research, and experimental research). For this reason, action research is particularly effective when employed in combination with Popper’s “falsifiability criterion.”

The business process redesign project focused on the Computer Sciences Corporation, from whom the DoD purchased software, and its software development procurement process. The Computer Sciences Corporation is the 13th largest defense contractor in the U.S. and ranks 2nd in information technology contracts. The business process redesign team had nine members; six are from Computer Sciences Corporation and three from Lockheed Martin, a company that was a subcontractor for Computer Sciences Corporation in many software development projects. (Lockheed Martin also regularly subcontracted Computer Science Corporation.) DoD members also participated in the project as information providers but not as members of the business process redesign team.

Process Redesign Work and Information-Flow Focus

An analysis conducted by the business process redesign team of the target process led to the identification of several problems, including the following:

- The work plan in the software development proposal developed for the DoD often did not include all the departments that participated in the actual work; thus, internal budgeting difficulties developed.

- The justification of the items in the Basis of Estimates (BOEs) document, which forms the basis on which the budget is generated, often did not meet the needs of the DoD.
- Participating departments were not informed on time about how much project funding was allocated to them; and, as a result, they were often forced to transfer initial overhead costs to other projects.

- Because there were no process metrics in place, the contracts manager at Computer Sciences Corporation had difficulty managing process quality and productivity.

- There were incidents when proposal data was lost; and, as a result, many hours of work were wasted. Also, disaster recovery procedures were not in place.

The business process redesign team employed activity-flow as well as information-flow modeling tools. The activity-flow modeling tool used was the functional timeline flowchart, as proposed by Harrington (1991) and Harrington et al. (1998). It incorporated information about the organizational functions involved in the process (e.g., contracts manager, program manager, technical lead, etc.), the activities carried out by each organization function, the order of execution of each activity in relation to other activities, the "process time" for each activity (i.e., the amount of time required to perform each activity), and the "cycle time" for each activity (i.e., the elapsed time between the end of the activity and the end of the previous activity). See Appendix B for a sample functional timeline flowchart generated by the business process redesign team.

The information-flow modeling tool used was a modified version of the "data-flow diagram" used in structured systems analysis and design (Davis, 1983; Dennis and Wixom, 2000), as proposed and illustrated by us in Chapter 3 of this report. It incorporated information about the organizational functions involved in the process (e.g., contracts manager, program manager, technical lead, etc.), the activities carried out by each organizational function, the information flows between organizational functions, and the information repositories in the business process. See Appendix B for a sample data-flow diagram generated by the business process redesign team.

Without interference from the facilitator, the redesign team independently proposed nine major business process changes based on the redesign guidelines listed in Appendix C. A content analysis of the descriptions of the proposed changes indicated the following breakdown according to their foci:

- Eight focused only on the information flow of the target business process and led to changes in the Request for Proposals (RFP) receipt and announcement, Alpha Negotiations, and receipt and announcement of project awards.

- One focused on both the activity and information flow of the target business process and led to the inclusion of activities related to the compilation and regular review of process metrics.

The team generated a functional timeline flowchart and a data-flow diagram of the new process, including the proposed changes above. The team then developed a "generic" information technology "solution" (i.e., a product-independent, computer-based infrastructure and system specification) to implement the new business process. The solution was illustrated through a rich pictorial representation with icons representing computers, databases, and organizational functions. The redesign team members saw this pictorial representation as an important aid for them to use when explaining the new process to Computer Science Corporation employees and DoD representatives. The pictorial representation was generated entirely based on the information-flow representation of the new process.

A focus group discussion was conducted with the members of the business process redesign team immediately after the above tasks had been completed. In this discussion the members unanimously indicated that, based on their experience in the project, a focus on the information flow of

a business process was more likely to lead to successful redesign outcomes than would a focus on the activity flow of the business process. However, there was no consensus on the reason for this. Some suggested that information-flow representations were easier to generate than activity-flow representations of business processes. Others disagreed, arguing that, while information-flow representations were more difficult to generate, they made it easier to spot business process improvement opportunities.

All of the process changes proposed by the redesign team were approved and subsequently implemented. The implementation of the process changes was accomplished through modifications in the computer system used by the DoD for procurement. This computer system is known as the Joint Computer-aided Acquisition and Logistics Support (JCALS) system, and it was originally developed by the Computer Sciences Corporation. A process performance review conducted approximately 6 months after the implementation of the changes indicated that the business process redesign outcomes led to productivity and quality gains.

Discussion and Conclusion

The evidence from the business process redesign project provides support to hypothesis H1a and, more importantly, fails to support H1b, which is the negative form of H1a. The most relevant pieces of evidence are briefly discussed below:

H1a states that, "Business process redesign practitioners perceive approaches that focus on information flow as more effective than approaches that focus on activity flow." Key pieces of evidence in support of this hypothesis follow:

- The business process redesign team used only the information-flow representation to develop almost all (eight out of nine, or 88.89 percent) of their change recommendations. The remaining change recommendation was also based on the information-flow representation, although not exclusively.

- The pictorial representation of the "generic" information technology "solution" was generated entirely based on the information-flow representation of the new process.

- In the focus group discussion, conducted with the members of the business process redesign team immediately after completion of the process, they unanimously indicated that a focus on a business process information flow was more likely to lead to successful redesign outcomes than a focus on a business process activity flow.

H1b, the negative form of H1a, states that, "Business process redesign practitioners perceive approaches that focus on information flow as either less effective than or presenting the same effectiveness as approaches that focus on activity flow." The following items suggest a lack of evidence in support of this hypothesis:

- The business process redesign team favored the information-flow representation even though it had generated both activity-flow and information-flow representations of the

business process. Because the team was familiar with both representations, it is likely that, if the team had perceived both types of representation as equivalent in terms of effectiveness, they would not have favored one over another. If they had perceived the activity-flow representation as superior, they would likely have favored it over the information-flow representation.

- Even though the business process redesign team had generated both activity-flow and information-flow representations of the new business process (i.e., the business process resulting from the change recommendations) the pictorial representation of the "generic" information technology "solution" was based only on the information-flow representation of the new process. Since the members of the redesign team had both representations available to them, it is likely that, if they had perceived both types of representations as equivalent in terms of effectiveness, they would not have chosen one. Also, they would not have referred to that type of representation as more likely to lead to successful results, as they did in the focus group discussion. If they had perceived the activity-flow representation as superior, they would likely have favored it over the information-flow representation.

- One might argue that the team perceived the pictorial representation as of little importance. Otherwise, they might have used the activity-flow representation as a basis. Yet, it is clear from the evidence that the pictorial representation was seen as very important by the redesign team because it illustrated how information technology would enable the new process. Also, the team saw the pictorial representation as an important aid for explaining the new process to Computer Science Corporation employees and DoD representatives.

When considering the items above and the evidence of this study, it seems that business process redesign practitioners perceive approaches that focus on information flow as more useful and effective than approaches that focus on activity flow.

The evidence also suggests that the perceptions above are warranted. It indicates that business process redesign approaches focusing on information flow may not only be "perceived" as more effective but also may "actually" be more effective than the more pervasive approaches based on activity flows. The key reason for this conclusion is that the business process redesign project studied was a successful one. If the business process redesign project had been unsuccessful, the fact that practitioners favored one approach over another would be less meaningful.

This study suggests the need for a change of focus in business process redesign in the defense sector (and possibly elsewhere). The shift should be from approaches based on activity flow to those based on information flow, such as InfoDesign. Given the widespread use of approaches based on activity flow today and their high rate of failure (Champy, 1995; Nissen, 1998), such a change of focus may have a dramatic impact on future business process redesign practices and bottom-line business impact.

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AUTHOR NOTES

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Ned Kock is Assistant Professor in the Department of Computer and Information Sciences, Temple University, Philadelphia, PA. He holds a B.E.E. in electronics engineering, a M.Sc. in computer science, and a Ph.D. in information systems from the University of Waikato, New Zealand. Ned has been working as a systems analyst and organizational development consultant since 1987 and has provided services to several companies including HSBC Bamerindus Bank, PricewaterhouseCoopers, Johnson & Johnson, Rio de Janeiro State Construction Company, Westaflex, New Zealand Ministry of Agriculture and Fisheries, True North, and Day and Zimmermann. He is the author of three scholarly books, including *Process Improvement and Organizational Learning: The Role of Collaboration Technologies* (Idea Group Publishing, 1999). He has also authored articles in a number of journals including the *Acquisition Review Quarterly*, *Communications of the ACM*, *Journal of Organizational Computing and Electronic Commerce, Information & Management*, *Information Systems Journal*, and *Information Technology & People*. Ned is associate editor of the *Journal of Systems and Information Technology*, coeditor of *ISWorld's Professional Ethics Section*, and a member of the editorial board of the *Journal of Information Technology Cases and Applications*. Branches of the Brazilian, New Zealand, and U.S. governments, as well as several private organizations in these countries, have funded his research. His current research interests are on knowledge communication in organizations, the relationship between organizational cognition modes and competitiveness, and collaborative systems support effects on organizational cognition and improvement.

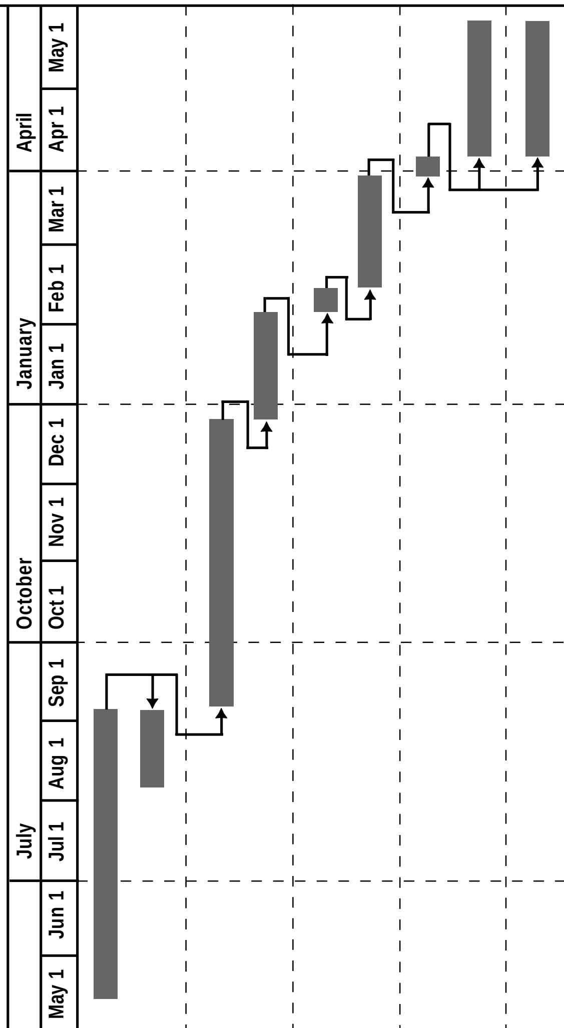
Frederic Murphy

Frederic H. Murphy is a Professor in the Department of Management Science/Operations Management in the Fox School of Business and Management at Temple University. He has a B.A. in mathematics (1968) and Ph.D. (1971) in the area of operations research from Yale University. Prior to joining Temple in 1982, he forecasted domestic energy markets at the Energy Information Administration (EIA) of the Department of Energy for several years. At the EIA he managed the development of a large-scale forecasting system with a team that included staff programmers and contractors. An important feature of the modeling system was that it redesigned the process by which the forecasts were developed, substantially reducing the workload of the forecasting team. As a summer research fellow at Resources for the Future, he worked on issues of energy security. He has also been a consultant to the EIA on the development of its latest forecasting system. He has published in the areas of operations research and energy policy analysis and modeling. He was the editor in chief of *Interfaces*, and he is an area editor of *Operations Research*.

APPENDIX A
PROJECT SCHEDULE

PROJECT SCHEDULE

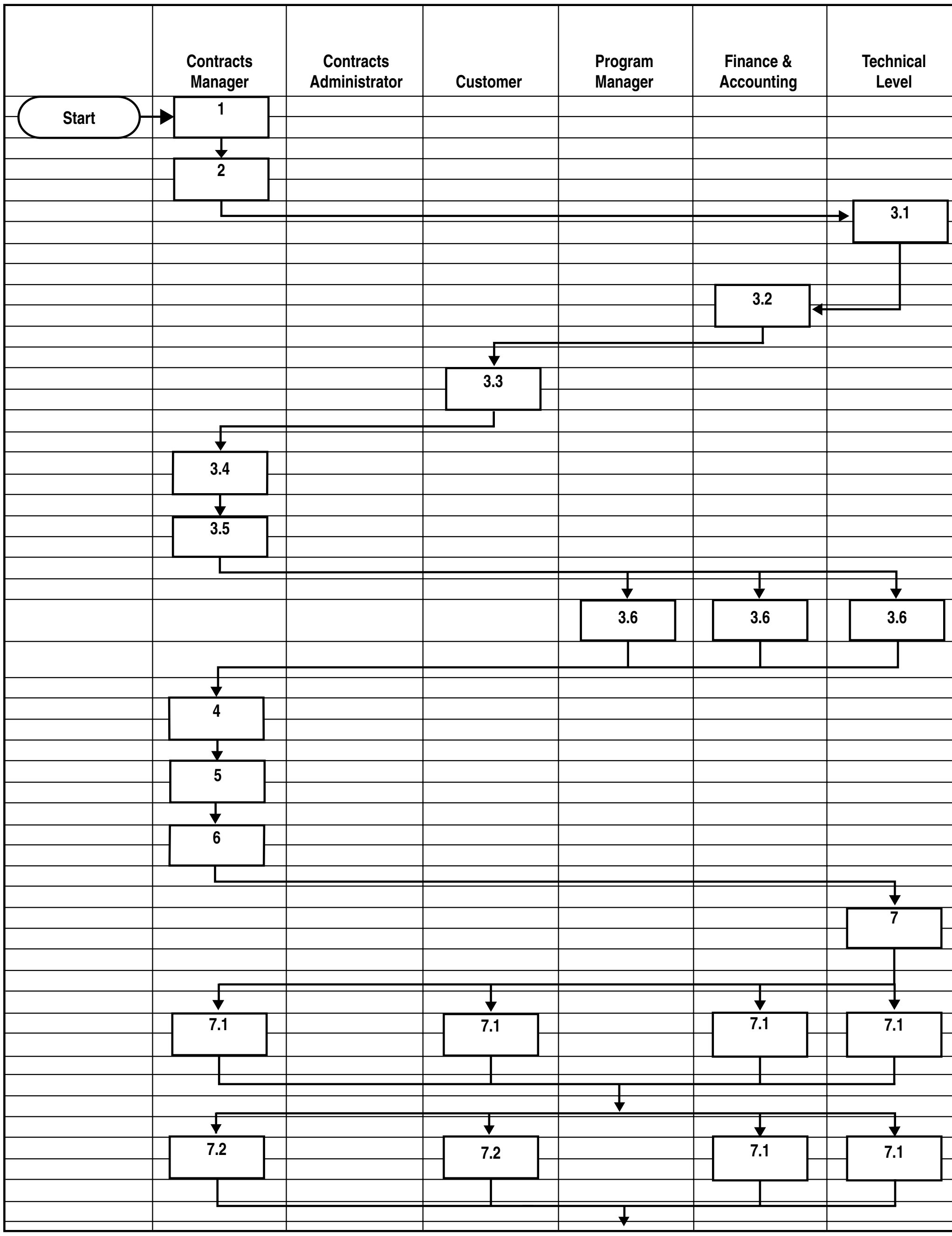
ID	Task Name	Duration	Start
1	Develop methodology	80 days	Wed 05/17/00
2	Develop support web site	20 days	Wed 08/09/00
3	Conduct validation (process redesign)	80 days	Wed 09/06/00
4	Write and submit 1st conference paper	30 days	Wed 12/27/00
5	Review process redesign implementation	5 days	Wed 02/07/01
6	Write and submit 2nd conference paper	30 days	Wed 02/14/01
7	Review process redesign implementation	5 days	Wed 03/28/01
8	Write and submit 2 journal articles	30 days	Wed 04/04/01
9	Write and submit final report	30 days	Wed 04/04/01



Project schedule
Date Fri 1/7/00

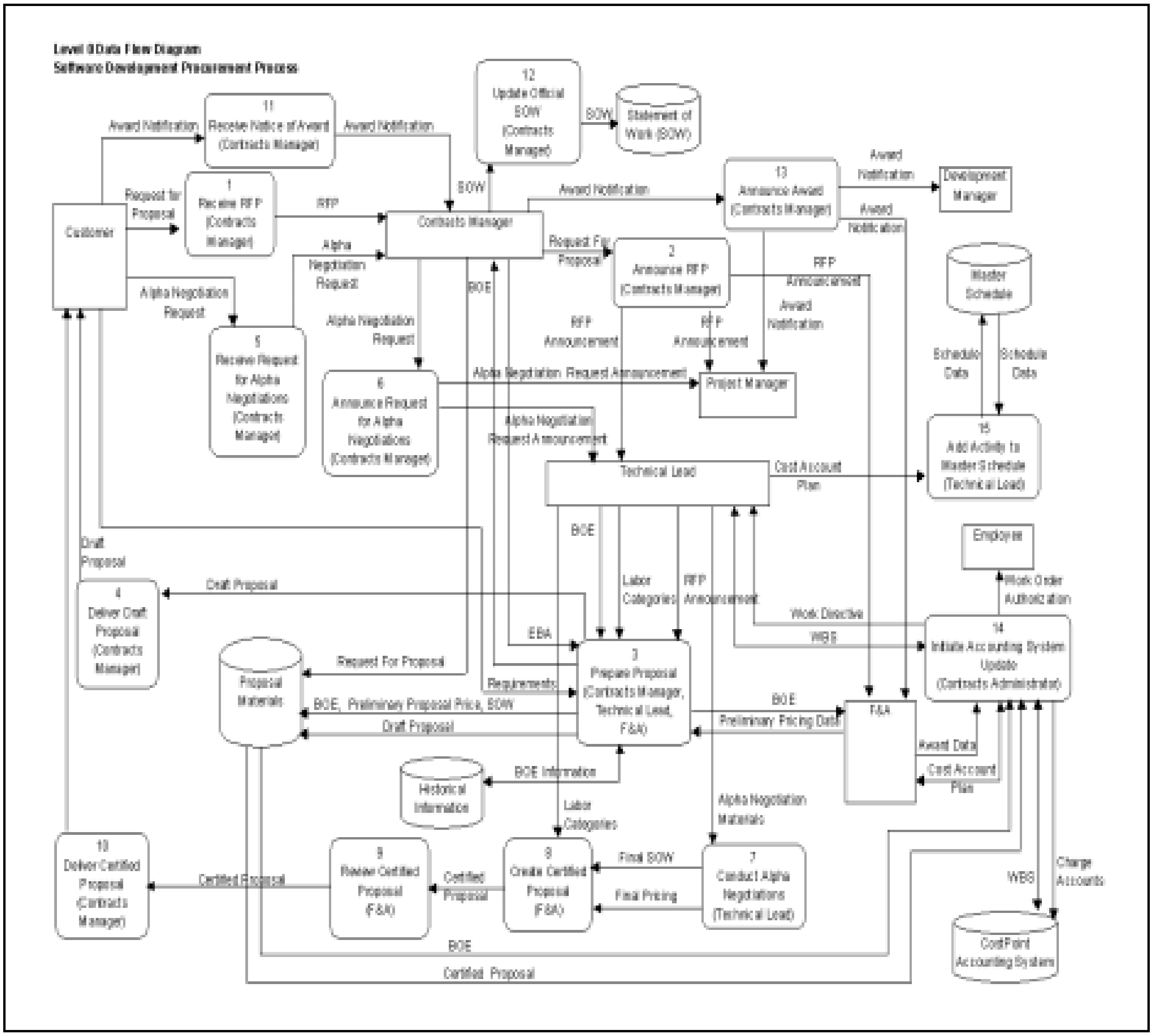
Task

APPENDIX B
ACTIVITY-FLOW AND DATA-FLOW DIAGRAMS USED



Activity	Processing Time (Days)	Cycle Time (Days)
1	1	1
2	1	1
3.1	1	1
3.2	5	10
3.3	1	1
3.4	5	10
3.5	7.5	20
3.6	3	5
4	1	1
5	0.5	2
6	3	5
7	5	10
7.1	3	5
7.2	3	5
8	1	2
9	2.5	5
10	3	5
11	1	1
12	1	1
13	1	3
14	3	5
14.1	1	1
14.2	1	1
14.3	2	4
14.3.1	2	5
14.3.3	1	1
14.4	1	1
15	1	1
	62.5	114

Sample Functional Timeline Flowchart Generated by the Redesign Team
(Activity names were listed next to the diagram.)



Sample Data-flow Diagram Generated by the Redesign Team

APPENDIX C
BUSINESS PROCESS REDESIGN GUIDELINES USED

The business process redesign team used the following guidelines, compiled from a large body of literature on business process redesign. These guidelines are discussed in more detail in Chapter 3 of this report. In the list below, the name of the technique is followed by a brief description of why the technique may lead to business process improvement. This information is provided here for quick reference. (Note: There will be some overlapping between the descriptions below and those provided in Chapter 3.)

- ***Foster asynchronous communication***. When people exchange information, they can do it synchronously (i.e., interacting at the same time) or asynchronously (i.e., interacting at different times). One example of synchronous communication is a telephone conversation. If the conversation takes place via E-mail, it then becomes an example of asynchronous communication. It has been observed, especially in formal business interaction, that asynchronous communication is almost always more efficient. For example, synchronous communication often leads to time waste (e.g., waiting for the other person to be found), and communication tends to be less objective. Asynchronous communication can be implemented with simple artifacts, such as in-boxes and out-boxes, fax trays, and billboards. These artifacts work as dynamic information repositories.

- ***Eliminate duplication of information***. Static repositories, as opposed to dynamic repositories, hold information on a more permanent basis. A student file maintained by a primary school, for example, is a static repository of information. Conversely, the data entry form used to temporary store student information that will be entered into the student file is not a static repository. Duplication of information in different static repositories often creates inconsistency problems, which may have a negative impact on productivity and quality. Kock (1995) describes a situation where a large automaker's purchasing division tried to keep two supplier databases updated. One database was updated manually and the other through a computer system. Two databases were being kept because the computer database had presented some problems and, therefore, was deemed unreliable. This, in turn, caused a large number of inconsistencies between the two databases. Each database stored data regarding over 400 parts suppliers.

- ***Reduce information flow.*** To the detriment of effectiveness, excessive information flow is often caused by an over-commitment to efficiency. Information is perceived as an important component of processes, and this perception drives people to an unhealthy information hunger. This hunger causes information overload and the creation of unnecessary information processing functions within the organization. Information overload leads to stress and, often, the creation of information filtering roles. These roles are normally those of aides or middle managers, who are responsible for filtering in the important bit from the information coming from both the bottom and outside of the organization. Conversely, excessive information that flows top-down forces middle managers to become messengers and, thus, damages their more important roles. Information flow can be reduced by selecting the information that is important in processes, eliminating the rest, and by effectively using group support and database management systems.

- ***Reduce control.*** Control activities do not normally add value to customers. They are often designed to prevent problems from happening as a result of human mistakes. In several cases, however, control itself fosters neglect and has a negative impact on productivity. For example, knowing that there will be some kind of control to catch mistakes, a worker may not be careful enough when performing a process activity. Additionally, some types of control, such as those aimed at preventing fraud, may prove to be more costly than no control at all. Some car insurance companies, for example, have determined that the cost of accident inspections for a large group of customers was much more expensive than the average cost of frauds committed by that group.

- ***Reduce the number of contact points.*** Contact points can be defined as points where interaction between two or more people, both inside and outside of the process, occurs. This involves contacts between functions and between functions and customers. Contact points generate delays and inconsistencies and, when in excess, lead to customer perplexity and dissatisfaction. For example, in self-service restaurants and warehouses, the points of contact were successfully reduced to a minimum. Additionally, it is much easier to monitor customer perceptions in situations where there are a small number of contact points. This makes it easier to improve process quality.

- ***Execute activities concurrently.*** Activities are often executed in sequence, even when they could be done concurrently. This has a negative impact primarily on productivity and is easier to spot on process flowcharts than in data-flow diagrams. For example, in a car assembly process, doors and other body parts can be assembled concurrently with some engine parts; and, by redesigning their processes accordingly, several automakers noted that the assembly of certain car models was significantly speeded up.

- ***Group interrelated activities.*** Closely interrelated activities should be grouped in time and space. Activities that use the same resources (i.e., artifacts or functions) may be carried out at the same location and, in some cases, at the same time. Ned Kock (1999) illustrates this point using the case of a telephone company that repaired external and internal house telephone connections. This company had two teams, one team performed internal repairs and the other performed external repairs. Internal repairs occur (by definition) within the boundaries of a commercial building or residence, and external repairs involve problems outside these boundaries. Whenever a customer complaint was received, the telephone company sent its internal team first. Should this team find no internal connection problem, the external team would then be dispatched to check the problem. A process improvement group determined that most of the problems were external; and, by not combining the two teams into a single repair team, the company was wasting thousands of dollars a year and upsetting their customers due to repair delays

- ***Break complex processes into simpler ones.*** Complex processes with dozens (hundreds in some cases) of activities and decision points should be "broken" into simpler ones. It is often much simpler to train workers to execute several simple processes than one complex process. It is also easier to avoid mistakes in this way because simple processes are easy to understand and coordinate. In support of this point, Ned Kock (1999) presented the case of an interna-

tional events organizer, which was structured around two main processes — the organization of national and international events. After a detailed analysis of these two processes, which embodied over a hundred activities each, it was found that they both could be split into three simpler subprocesses — the organization of exhibitions, conferences, and exhibitor's participation. This simplification improved the learning curve for the processes and reduced the occurrence of mistakes. It did not, however, lead to an increase in the number of employees needed because, with simpler processes, one person could perform functions in various processes at the same time.